US012192602B2

(12) **United States Patent**
Shimotsu et al.

(10) **Patent No.: US 12,192,602 B2**
(45) **Date of Patent: Jan. 7, 2025**

(54) **IMAGING CONTROL DEVICE, OPERATION METHOD AND PROGRAM OF IMAGING CONTROL DEVICE, AND IMAGING DEVICE**

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(73) Assignee: **FUJIFILM Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 156 days.

(21) Appl. No.: **18/152,117**

(22) Filed: **Jan. 9, 2023**

(65) **Prior Publication Data**

US 2023/0171474 A1 Jun. 1, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2021/023987, filed on Jun. 24, 2021.

(30) **Foreign Application Priority Data**

Jul. 29, 2020 (JP) 2020-128580

(51) **Int. Cl.**
H04N 23/11 (2023.01)
G06T 5/50 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04N 23/11*** (2023.01); ***G06T 5/50*** (2013.01); ***G06V 10/60*** (2022.01); ***G06V 10/761*** (2022.01);
(Continued)

(58) **Field of Classification Search**
CPC H04N 23/11; G06V 10/60; G06T 5/50
See application file for complete search history.

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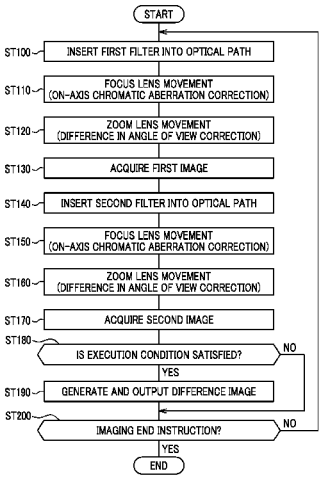
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

Provided are an imaging controller, an operation method and program of the imaging controller, and a camera capable of presenting a radiation image of a subject to a user in an easy-to-understand manner. An image sensor driving control unit causes an image sensor to image a visible ray to acquire a first image including a reflected image of a subject. The image sensor driving control unit causes the image sensor to image an infrared ray to acquire a second image including the reflected image and a radiation image of the subject. A zoom lens driving control unit moves a zoom lens along an optical axis to correct a difference in angle of view between the first image and the second image. Image processing units output difference images between the first image and the second image acquired in a state in which the difference in angle of view is corrected.

12 Claims, 17 Drawing Sheets



(51) **Int. Cl.**

G06V 10/60	(2022.01)
G06V 10/74	(2022.01)
H04N 23/55	(2023.01)
H04N 23/69	(2023.01)

(52) **U.S. Cl.**

CPC ***H04N 23/55*** (2023.01); ***H04N 23/69*** (2023.01); *G06T 2207/20224* (2013.01)

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FIG. 1

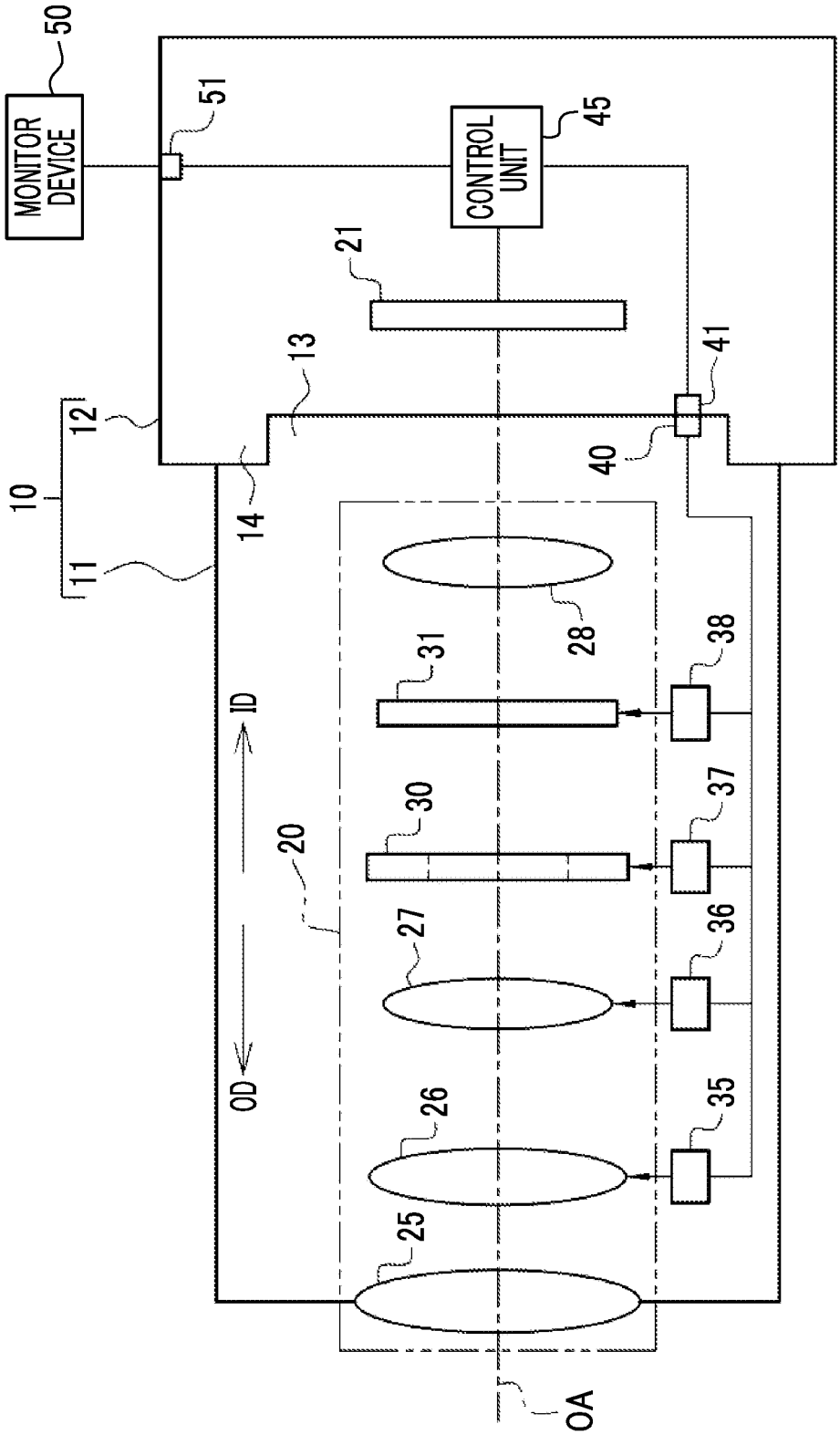

50
MONITOR DEVICE
51
CONTROL UNIT
45
21
13
41
12
40
10
14
11
28
31
38
ID
30
37
20
27
36
OD
26
35
25
OA

FIG. 2

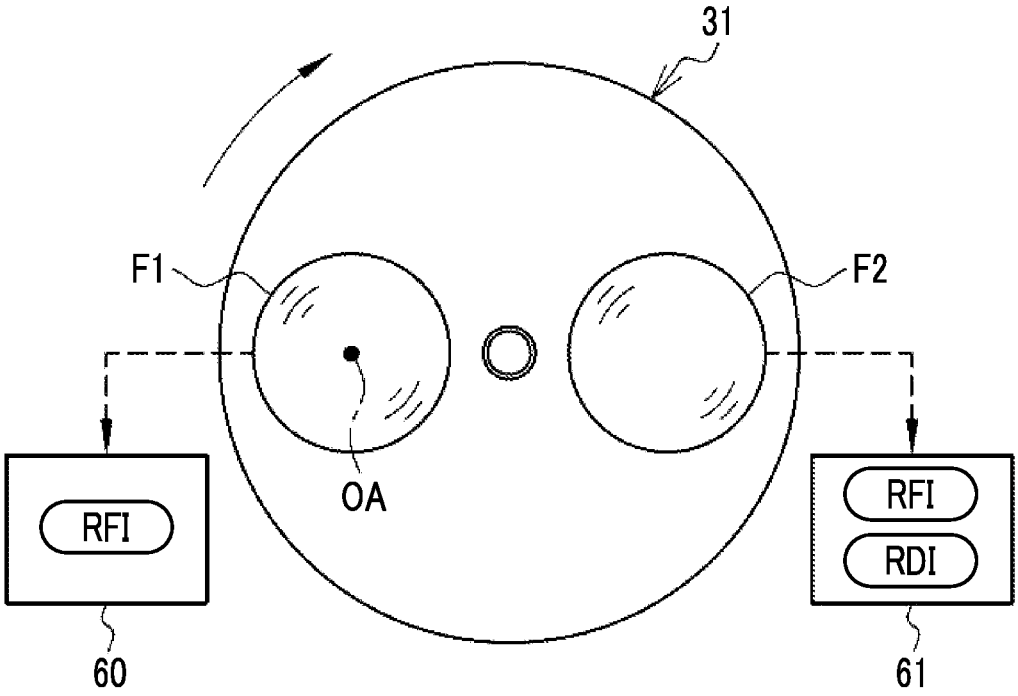

31
F1
F2
OA
RFI
RFI
RDI
60
61

FIG. 3

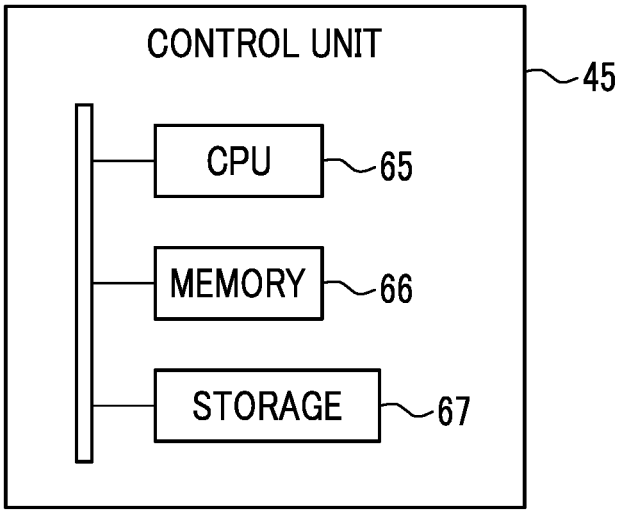

CONTROL UNIT
45
CPU
65
MEMORY
66
STORAGE
67

FIG. 4

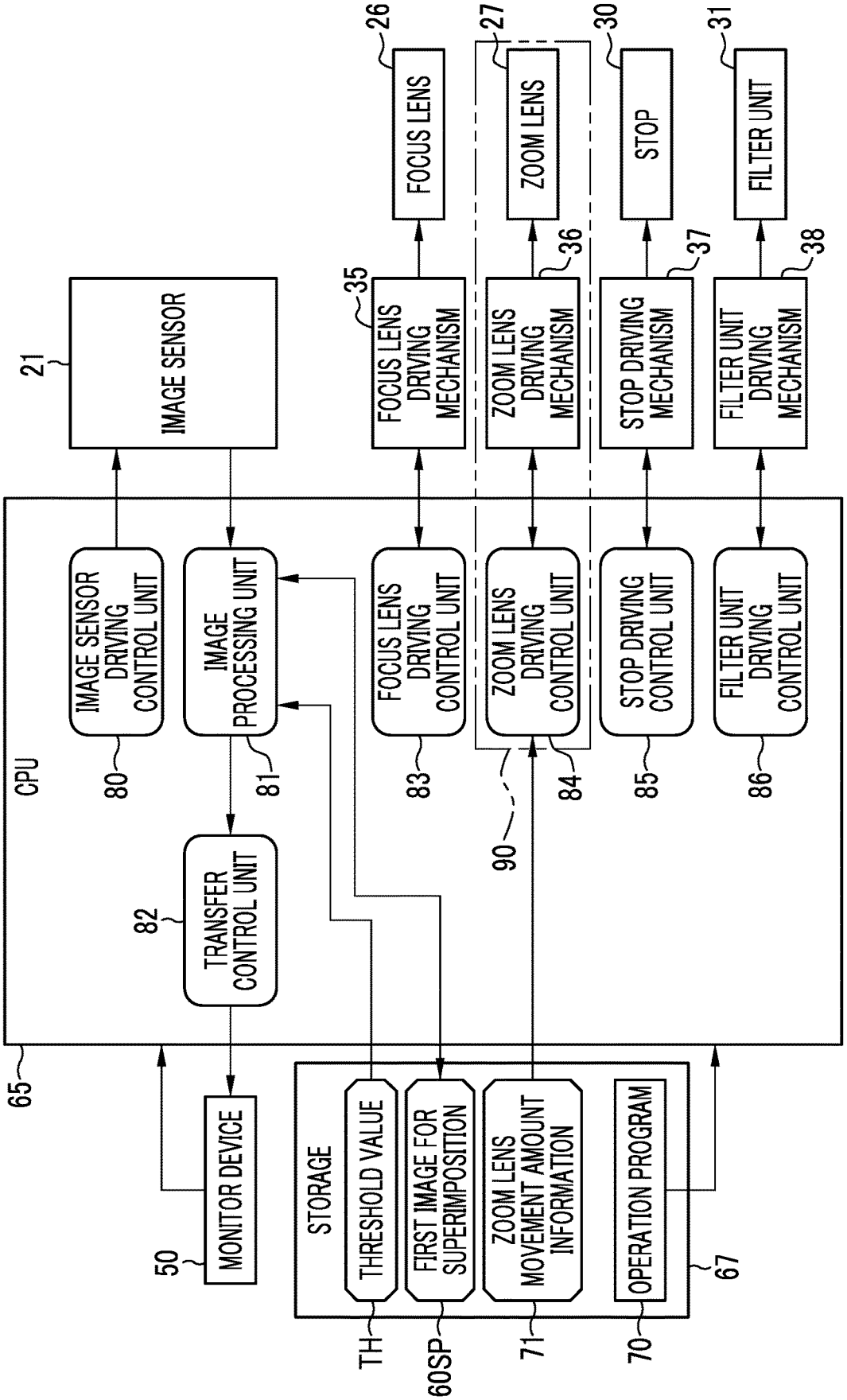

26
27
30
31
FOCUS LENS
ZOOM LENS
STOP
FILTER UNIT
35
36
37
38
FOCUS LENS DRIVING MECHANISM
ZOOM LENS DRIVING MECHANISM
STOP DRIVING MECHANISM
FILTER UNIT DRIVING MECHANISM
21
IMAGE SENSOR
CPU
IMAGE SENSOR DRIVING CONTROL UNIT
IMAGE PROCESSING UNIT
FOCUS LENS DRIVING CONTROL UNIT
ZOOM LENS DRIVING CONTROL UNIT
STOP DRIVING CONTROL UNIT
FILTER UNIT DRIVING CONTROL UNIT
80
81
83
84
85
86
90
82
TRANSFER CONTROL UNIT
65
50
MONITOR DEVICE
STORAGE
THRESHOLD VALUE
FIRST IMAGE FOR SUPERIMPOSITION
ZOOM LENS MOVEMENT AMOUNT INFORMATION
OPERATION PROGRAM
67
TH
60SP
71
70

FIG. 5

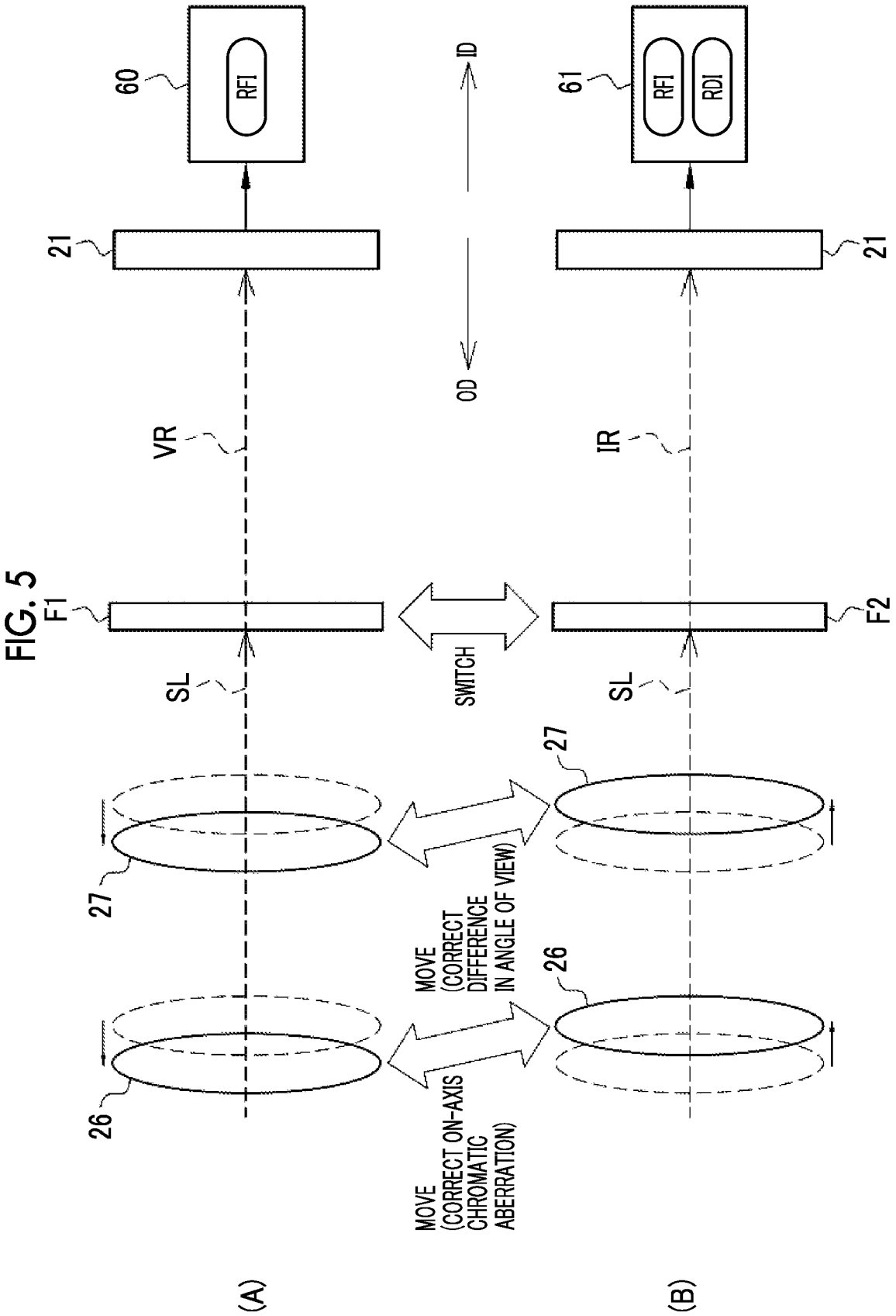

60
RFI
61
RFI
RDI
ID
OD
21
21
VR
IR
F1
F2
SWITCH
SL
SL
27
27
26
26
MOVE (CORRECT DIFFERENCE IN ANGLE OF VIEW)
MOVE (CORRECT ON-AXIS CHROMATIC ABERRATION)
(A)
(B)

FIG. 6

ZOOM LENS MOVEMENT AMOUNT INFORMATION 71

	POSITION OF ZOOM LENS	MOVEMENT AMOUNT OF ZOOM LENS REQUIRED FOR CORRECTION OF DIFFERENCE IN ANGLE OF VIEW (mm)
TELEPHOTO SIDE	Z1	0.25
	Z2	0.22
	Z3	0.2
	Z4	0.18
WIDE ANGLE SIDE	⋮	⋮

FIG. 7

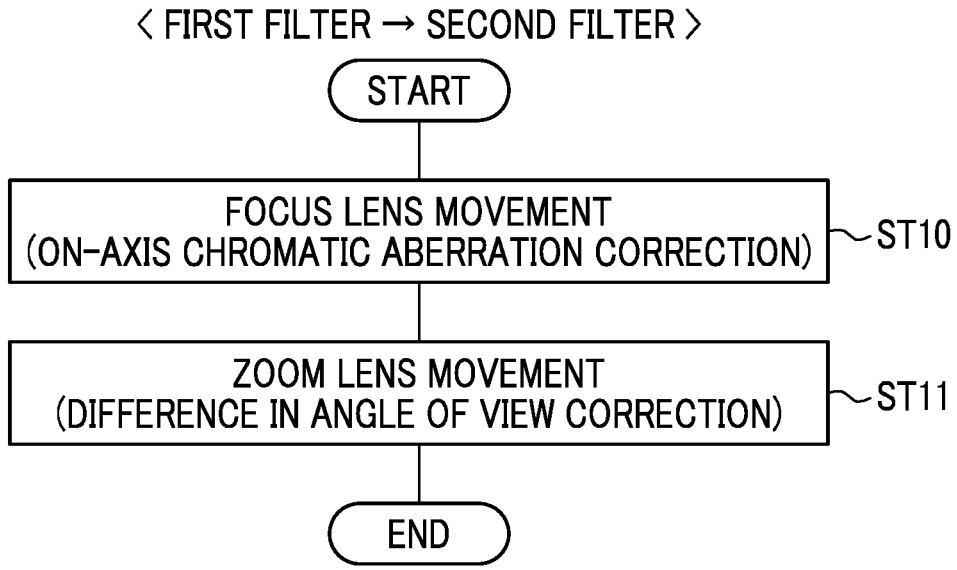


FIG. 8

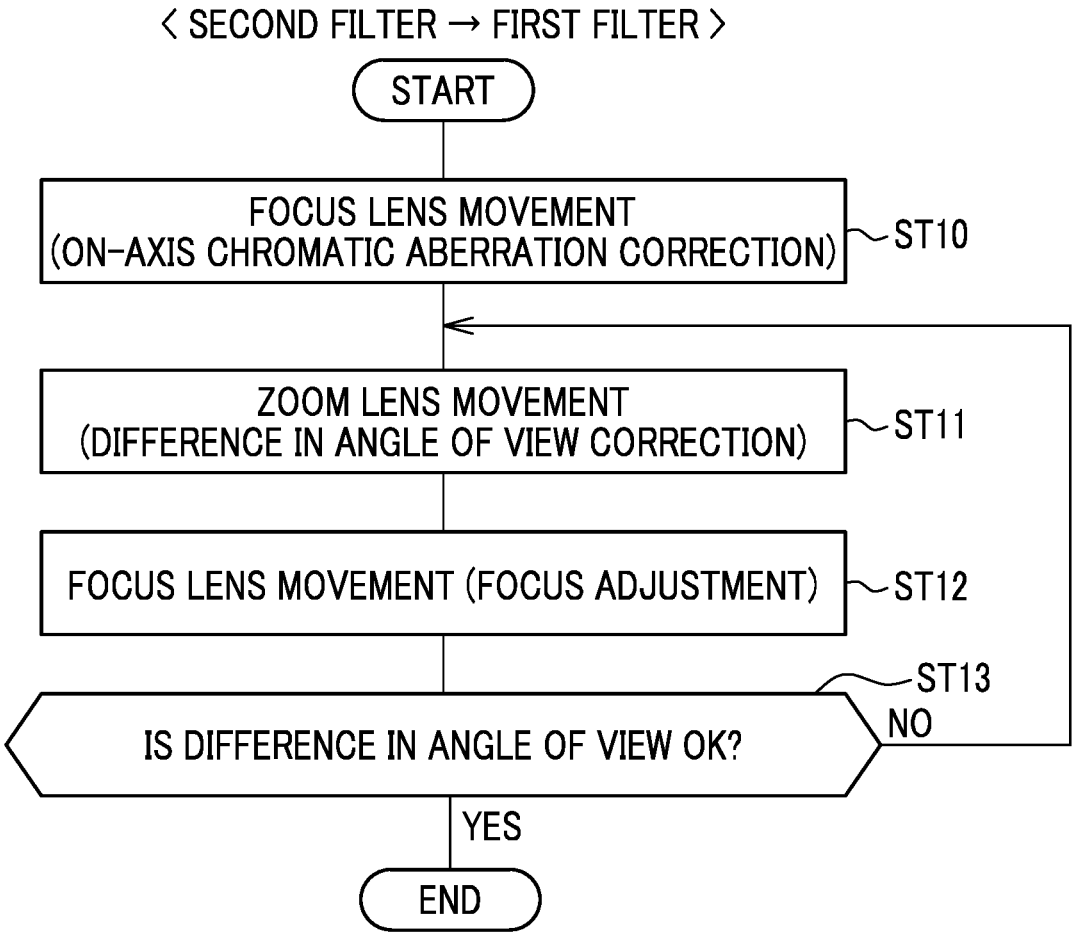

< SECOND FILTER → FIRST FILTER >
START
FOCUS LENS MOVEMENT
(ON-AXIS CHROMATIC ABERRATION CORRECTION)
ST10
ZOOM LENS MOVEMENT
(DIFFERENCE IN ANGLE OF VIEW CORRECTION)
ST11
FOCUS LENS MOVEMENT (FOCUS ADJUSTMENT)
ST12
ST13
IS DIFFERENCE IN ANGLE OF VIEW OK?
NO
YES
END

FIG. 9

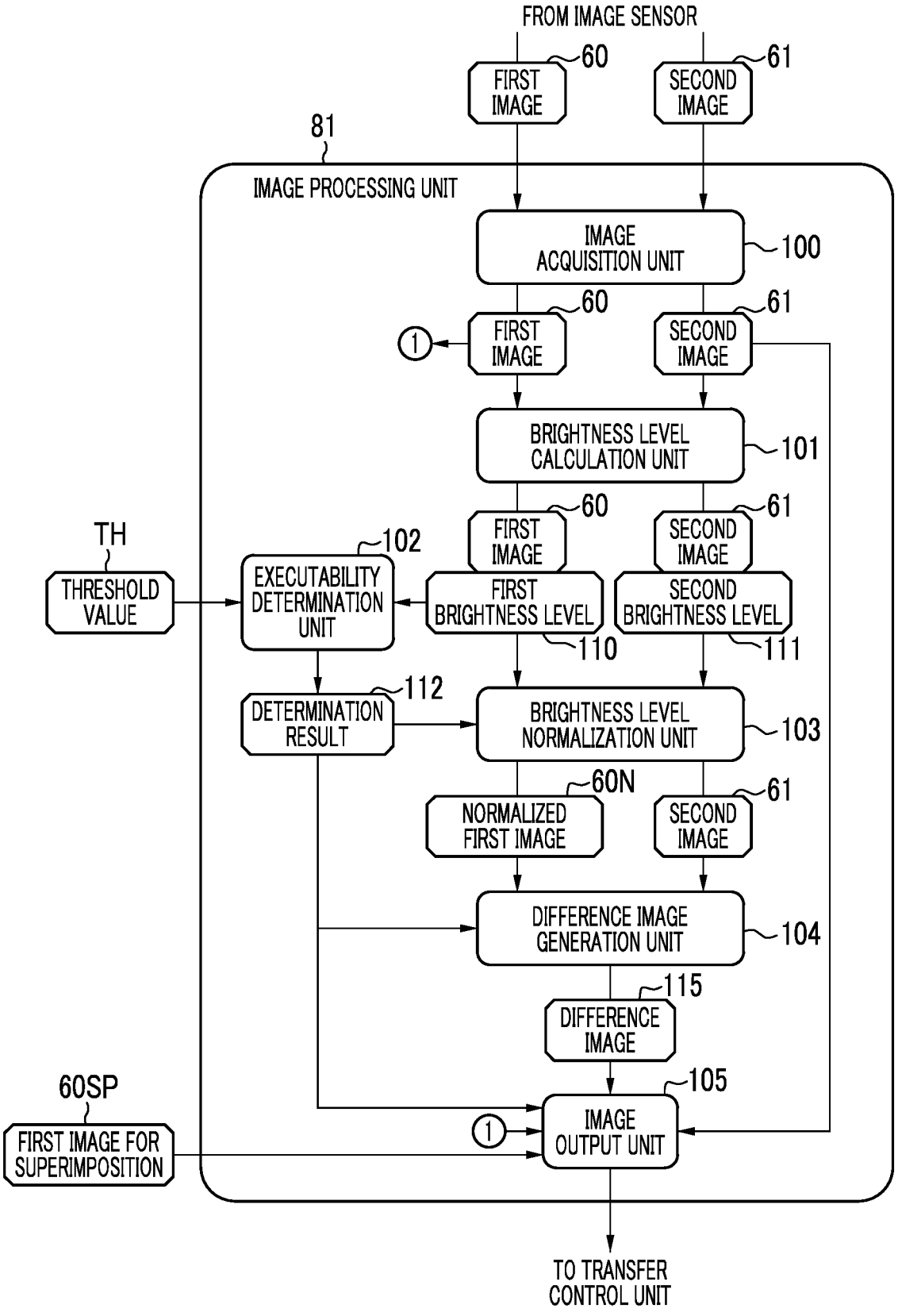

FROM IMAGE SENSOR
FIRST IMAGE
60
SECOND IMAGE
61
81
IMAGE PROCESSING UNIT
IMAGE ACQUISITION UNIT
100
1
BRIGHTNESS LEVEL CALCULATION UNIT
101
TH
THRESHOLD VALUE
102
EXECUTABILITY DETERMINATION UNIT
FIRST BRIGHTNESS LEVEL
110
SECOND BRIGHTNESS LEVEL
111
DETERMINATION RESULT
112
BRIGHTNESS LEVEL NORMALIZATION UNIT
103
NORMALIZED FIRST IMAGE
60N
DIFFERENCE IMAGE GENERATION UNIT
104
DIFFERENCE IMAGE
115
60SP
FIRST IMAGE FOR SUPERIMPOSITION
IMAGE OUTPUT UNIT
105
TO TRANSFER CONTROL UNIT

FIG. 10

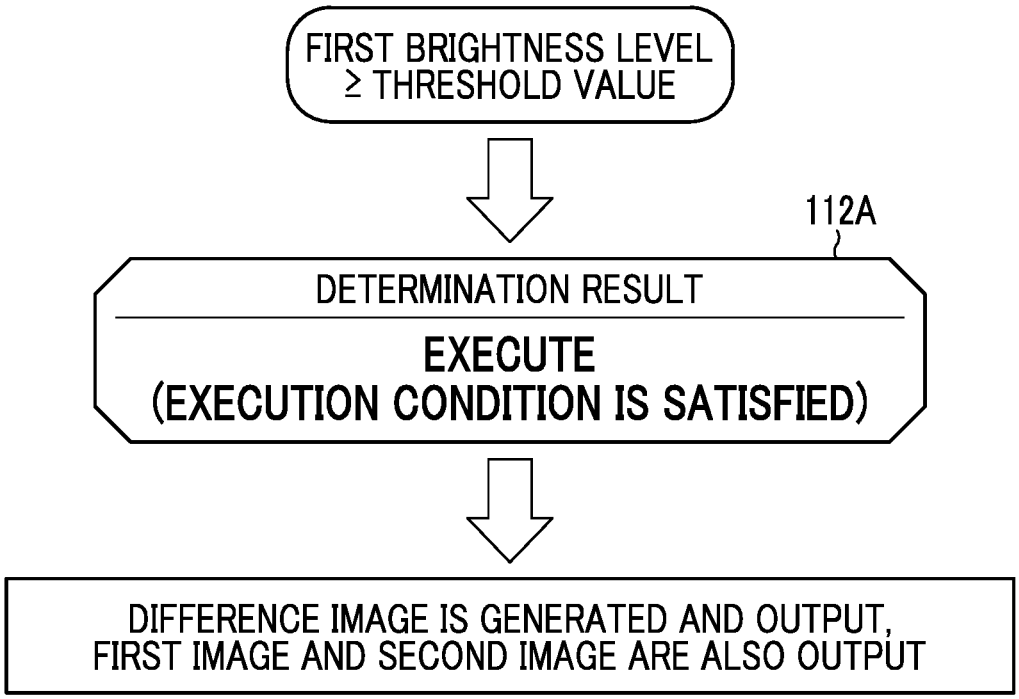

FIRST BRIGHTNESS LEVEL
≥ THRESHOLD VALUE
112A
DETERMINATION RESULT
EXECUTE
(EXECUTION CONDITION IS SATISFIED)
DIFFERENCE IMAGE IS GENERATED AND OUTPUT,
FIRST IMAGE AND SECOND IMAGE ARE ALSO OUTPUT

FIG. 11

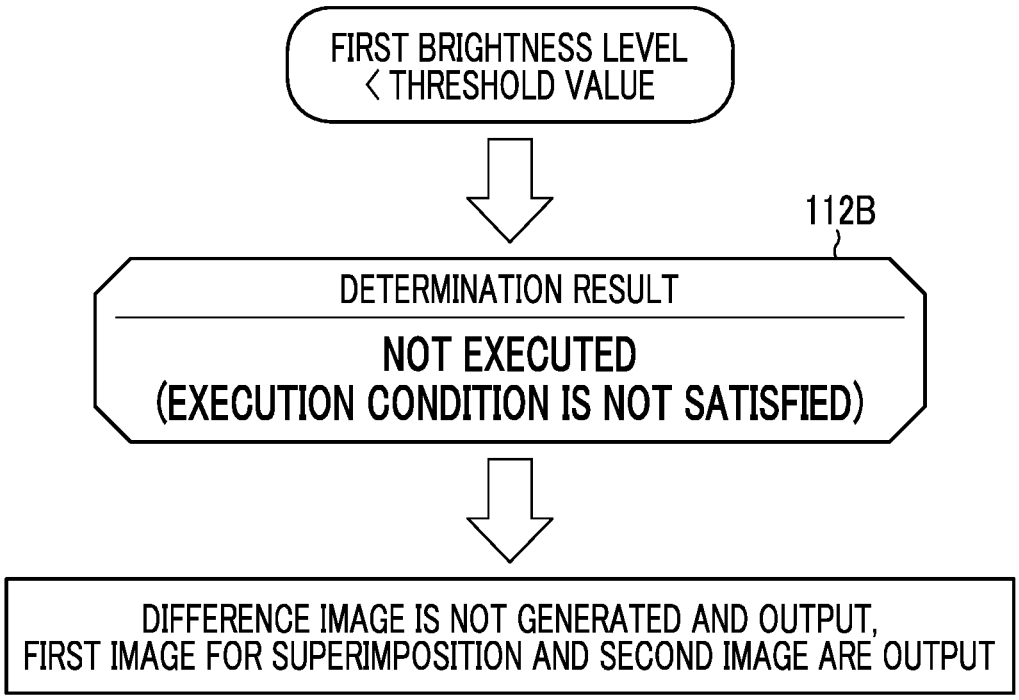

FIRST BRIGHTNESS LEVEL
< THRESHOLD VALUE
112B
DETERMINATION RESULT
NOT EXECUTED
(EXECUTION CONDITION IS NOT SATISFIED)
DIFFERENCE IMAGE IS NOT GENERATED AND OUTPUT,
FIRST IMAGE FOR SUPERIMPOSITION AND SECOND IMAGE ARE OUTPUT

FIG. 12

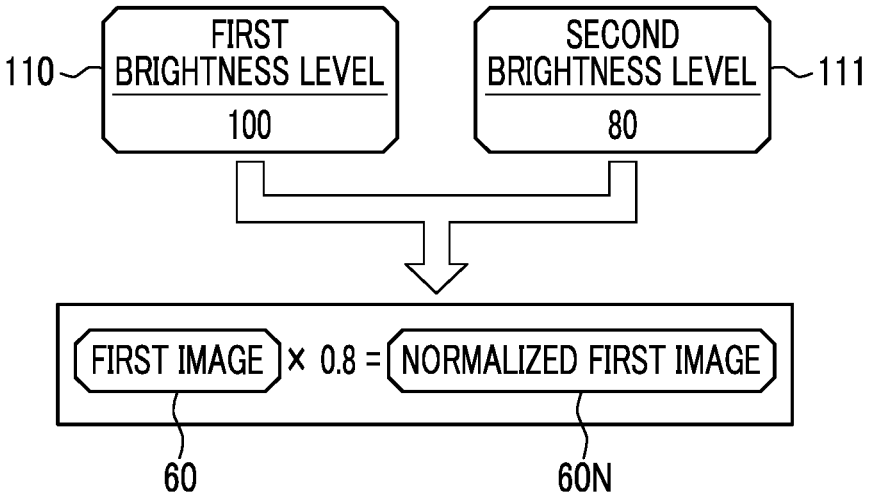

110
FIRST
BRIGHTNESS LEVEL
100
SECOND
BRIGHTNESS LEVEL
80
111
FIRST IMAGE
× 0.8 =
NORMALIZED FIRST IMAGE
60
60N

FIG. 13

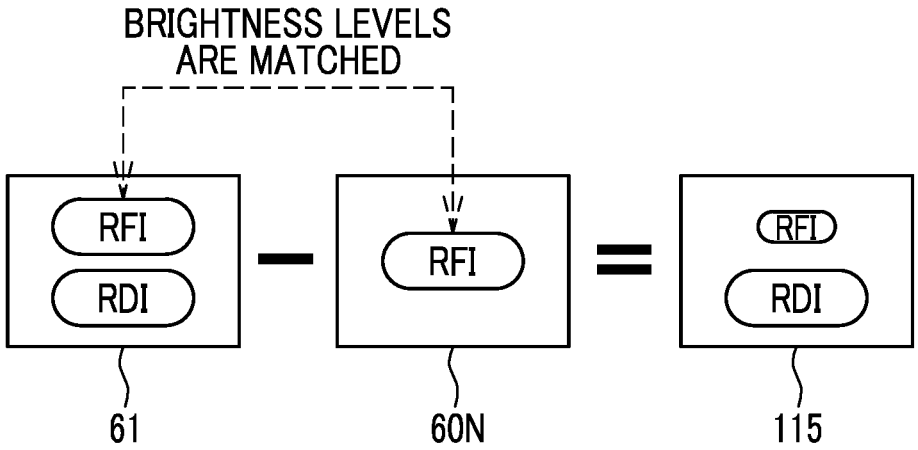

BRIGHTNESS LEVELS
ARE MATCHED
RFI
RDI
RFI
RFI
RDI
61
60N
115

FIG. 14

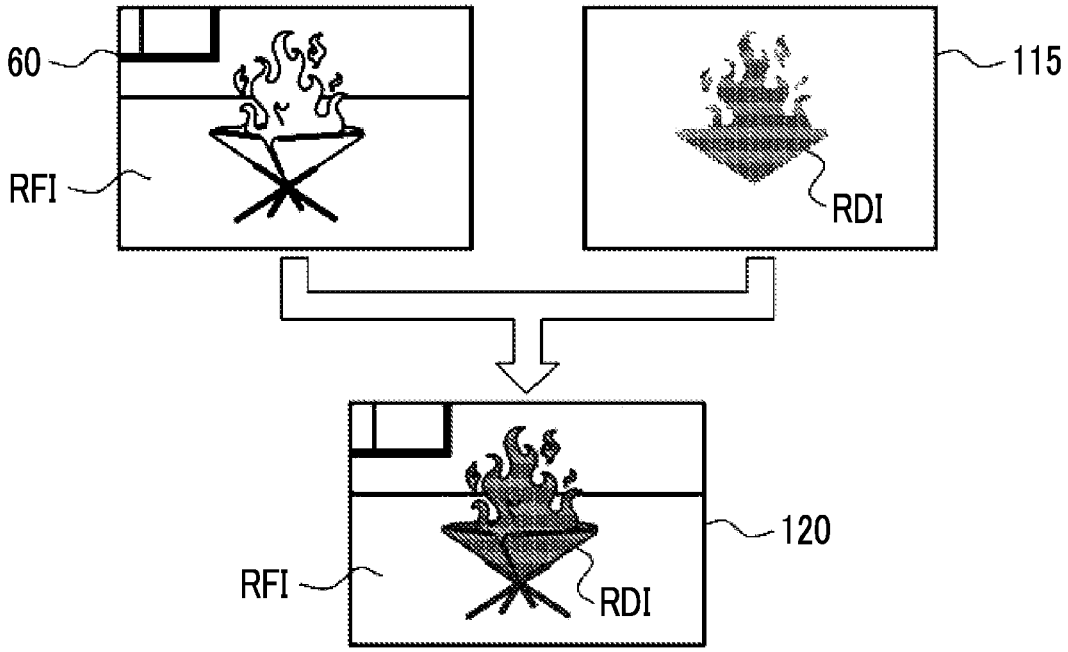


FIG. 15

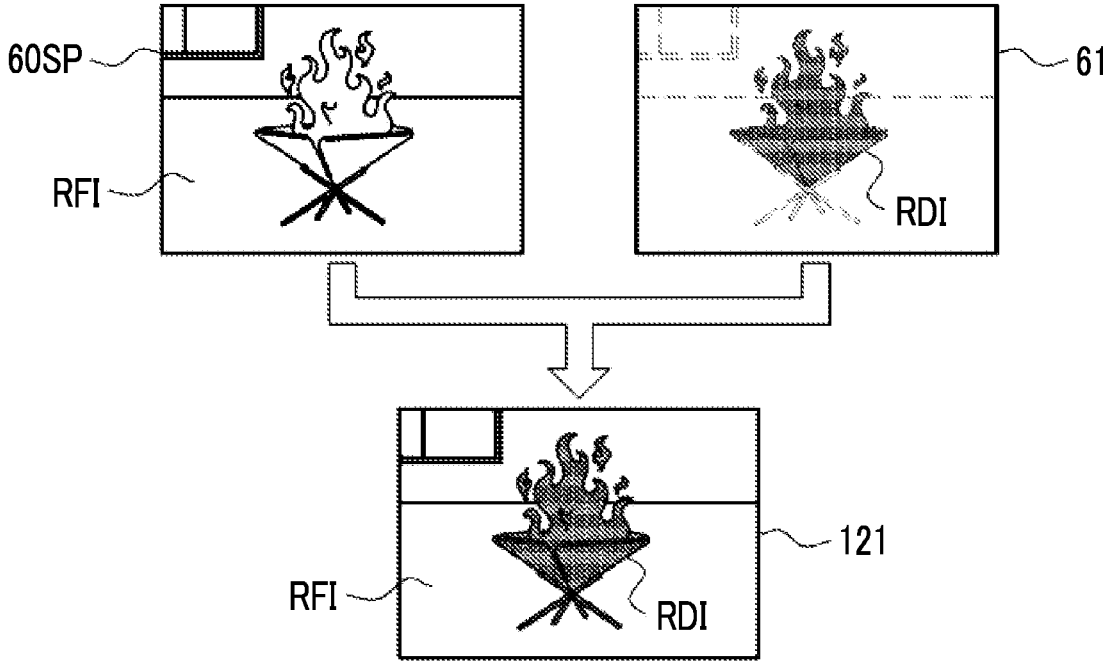


FIG. 16

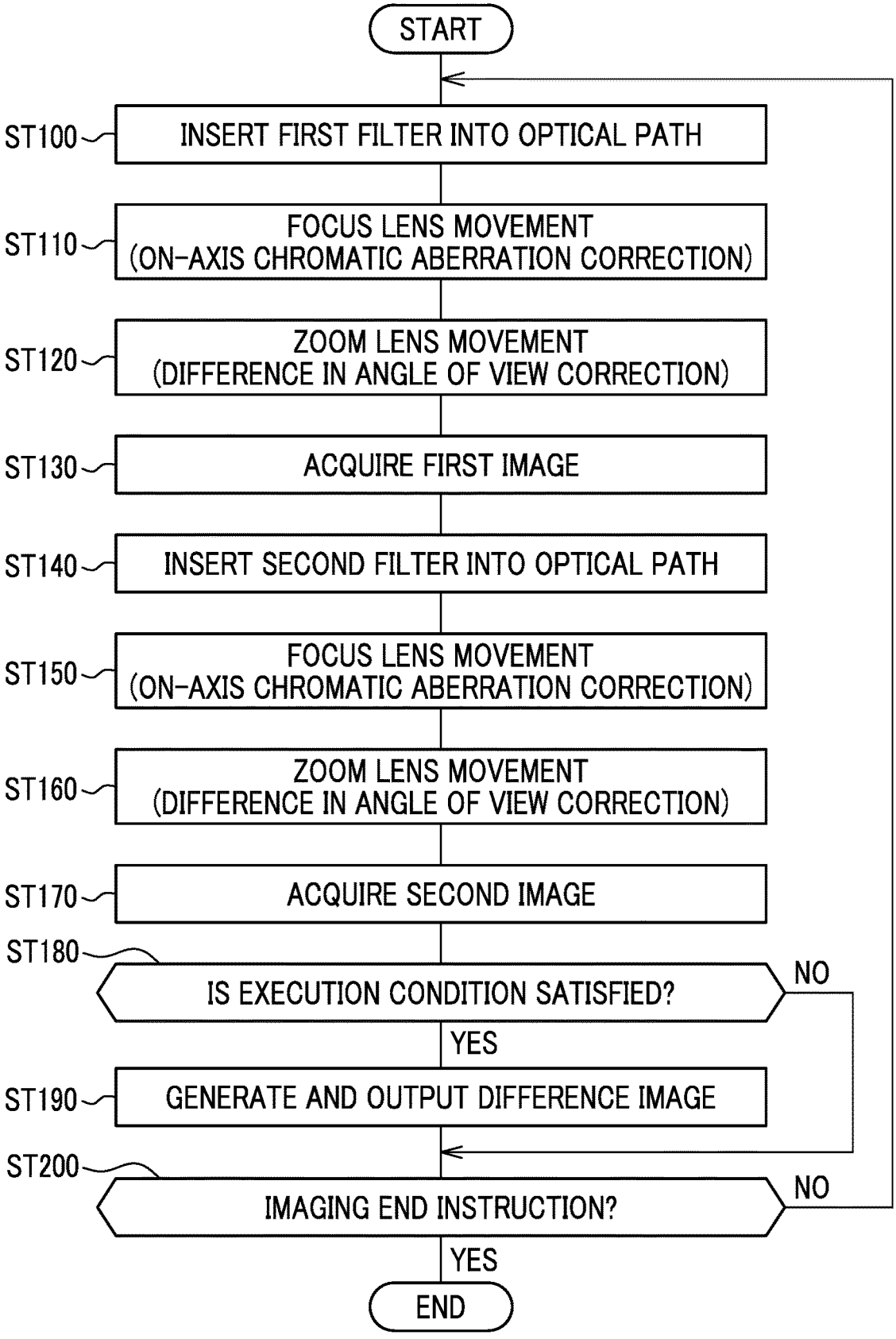

START
ST100
INSERT FIRST FILTER INTO OPTICAL PATH
ST110
FOCUS LENS MOVEMENT
(ON-AXIS CHROMATIC ABERRATION CORRECTION)
ST120
ZOOM LENS MOVEMENT
(DIFFERENCE IN ANGLE OF VIEW CORRECTION)
ST130
ACQUIRE FIRST IMAGE
ST140
INSERT SECOND FILTER INTO OPTICAL PATH
ST150
FOCUS LENS MOVEMENT
(ON-AXIS CHROMATIC ABERRATION CORRECTION)
ST160
ZOOM LENS MOVEMENT
(DIFFERENCE IN ANGLE OF VIEW CORRECTION)
ST170
ACQUIRE SECOND IMAGE
ST180
IS EXECUTION CONDITION SATISFIED?
NO
YES
ST190
GENERATE AND OUTPUT DIFFERENCE IMAGE
ST200
IMAGING END INSTRUCTION?
NO
YES
END

FIG. 17

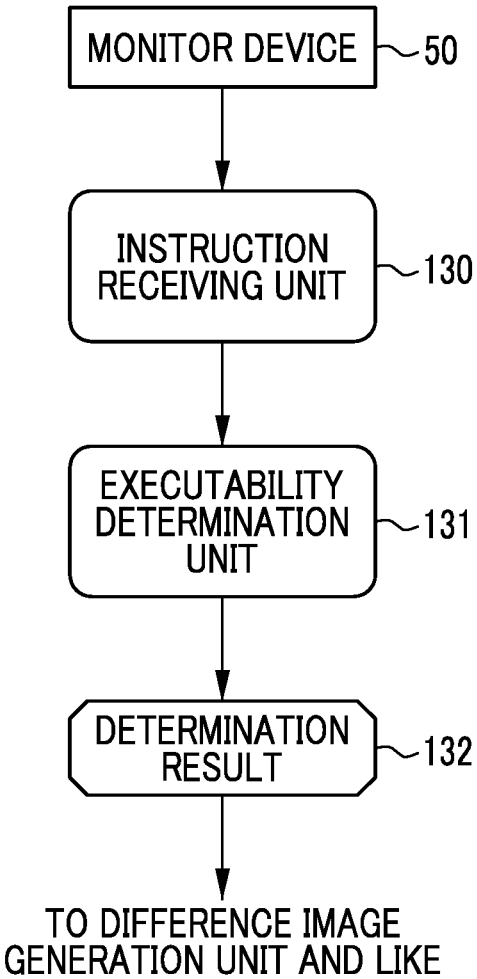

MONITOR DEVICE
50
INSTRUCTION RECEIVING UNIT
130
EXECUTABILITY DETERMINATION UNIT
131
DETERMINATION RESULT
132
TO DIFFERENCE IMAGE GENERATION UNIT AND LIKE

FIG. 18

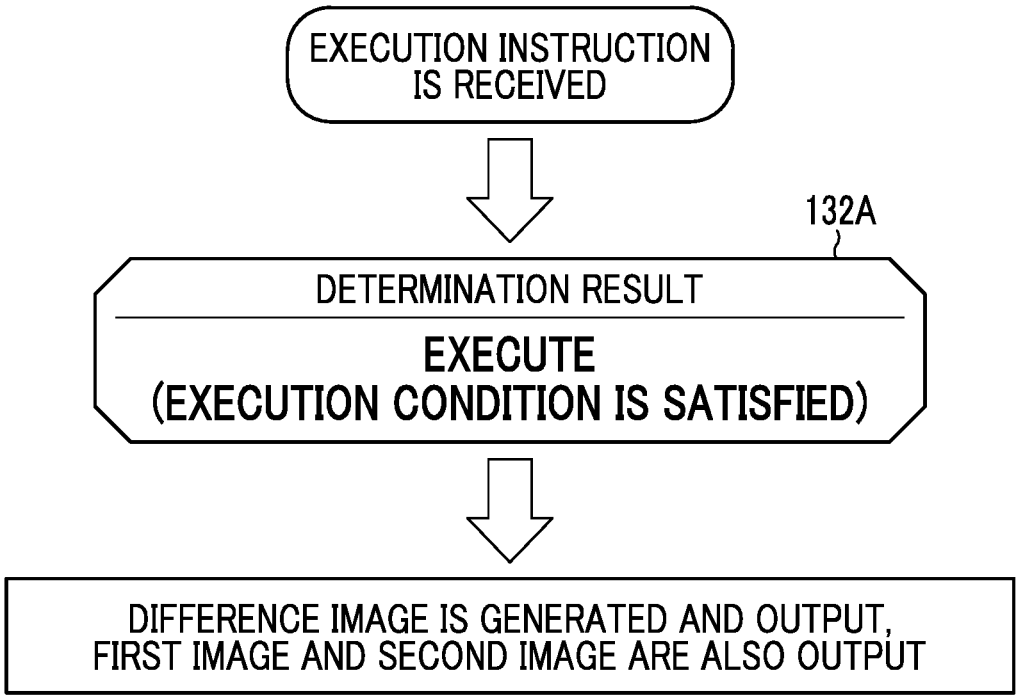

EXECUTION INSTRUCTION IS RECEIVED
132A
DETERMINATION RESULT
EXECUTE
(EXECUTION CONDITION IS SATISFIED)
DIFFERENCE IMAGE IS GENERATED AND OUTPUT, FIRST IMAGE AND SECOND IMAGE ARE ALSO OUTPUT

FIG. 19

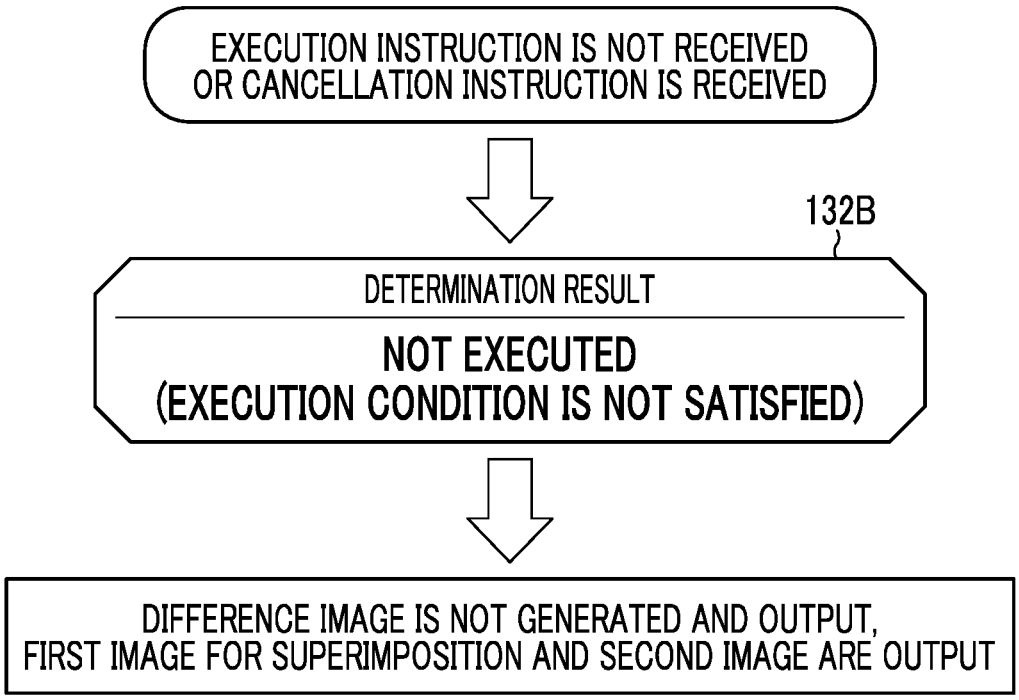

EXECUTION INSTRUCTION IS NOT RECEIVED OR CANCELLATION INSTRUCTION IS RECEIVED
132B
DETERMINATION RESULT
NOT EXECUTED
(EXECUTION CONDITION IS NOT SATISFIED)
DIFFERENCE IMAGE IS NOT GENERATED AND OUTPUT, FIRST IMAGE FOR SUPERIMPOSITION AND SECOND IMAGE ARE OUTPUT

FIG. 20

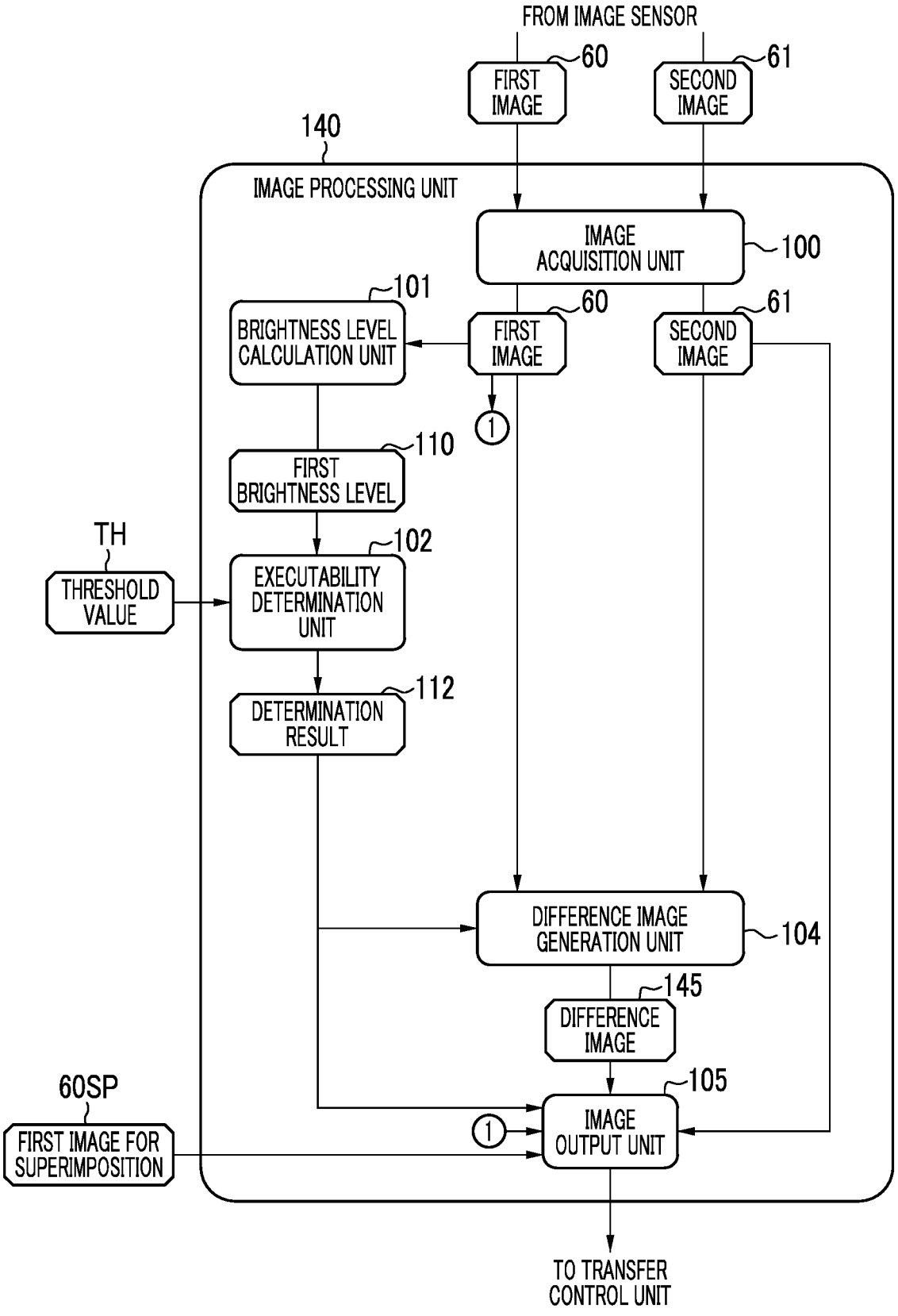

FROM IMAGE SENSOR
FIRST IMAGE
60
SECOND IMAGE
61
140
IMAGE PROCESSING UNIT
IMAGE ACQUISITION UNIT
100
101
BRIGHTNESS LEVEL CALCULATION UNIT
FIRST IMAGE
60
SECOND IMAGE
61
1
110
FIRST BRIGHTNESS LEVEL
TH
THRESHOLD VALUE
102
EXECUTABILITY DETERMINATION UNIT
112
DETERMINATION RESULT
DIFFERENCE IMAGE GENERATION UNIT
104
145
DIFFERENCE IMAGE
60SP
FIRST IMAGE FOR SUPERIMPOSITION
105
1
IMAGE OUTPUT UNIT
TO TRANSFER CONTROL UNIT

FIG. 21

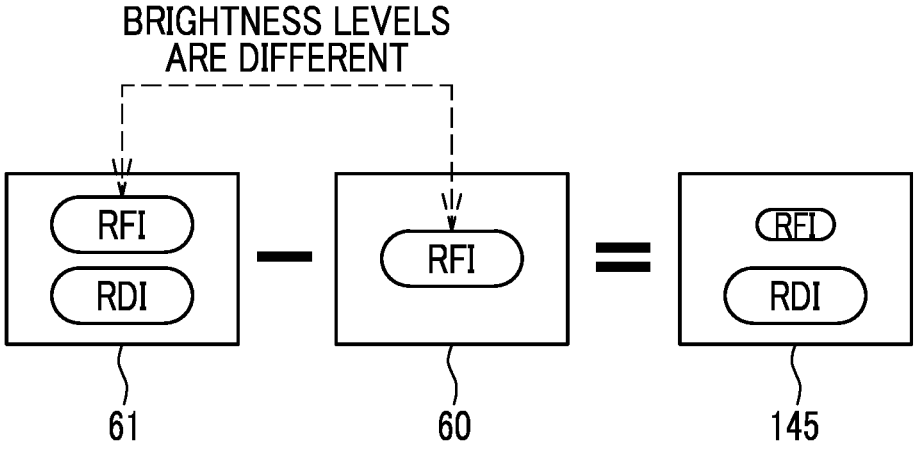

BRIGHTNESS LEVELS
ARE DIFFERENT
RFI
RDI
RFI
RFI
RDI
61
60
145

FIG. 22

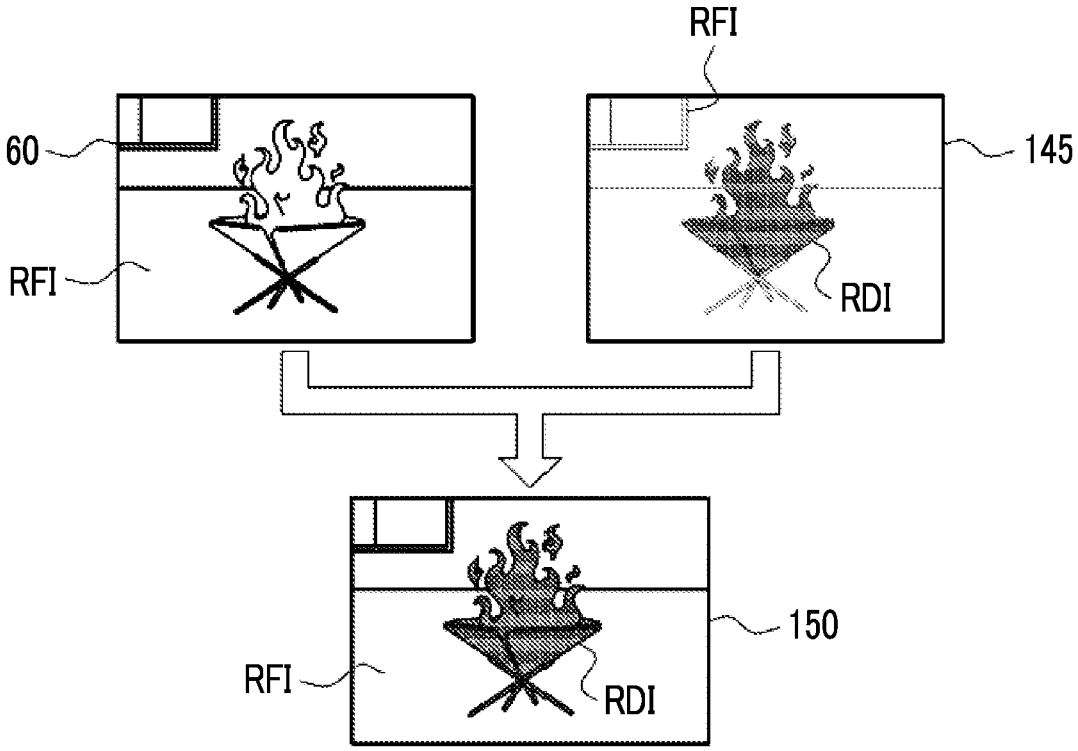

RFI
60
RFI
RDI
145
150
RFI
RDI

FIG. 23

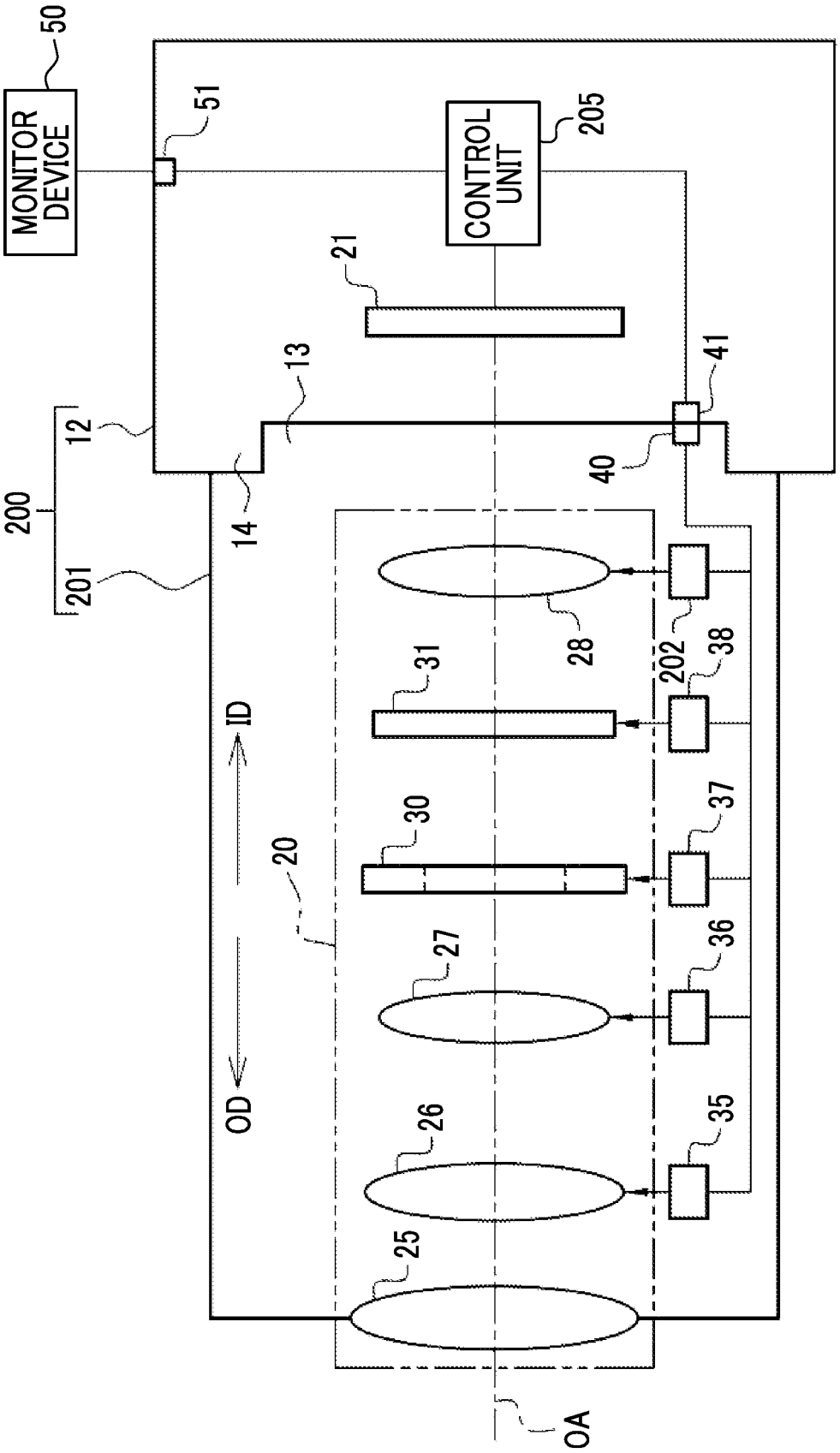
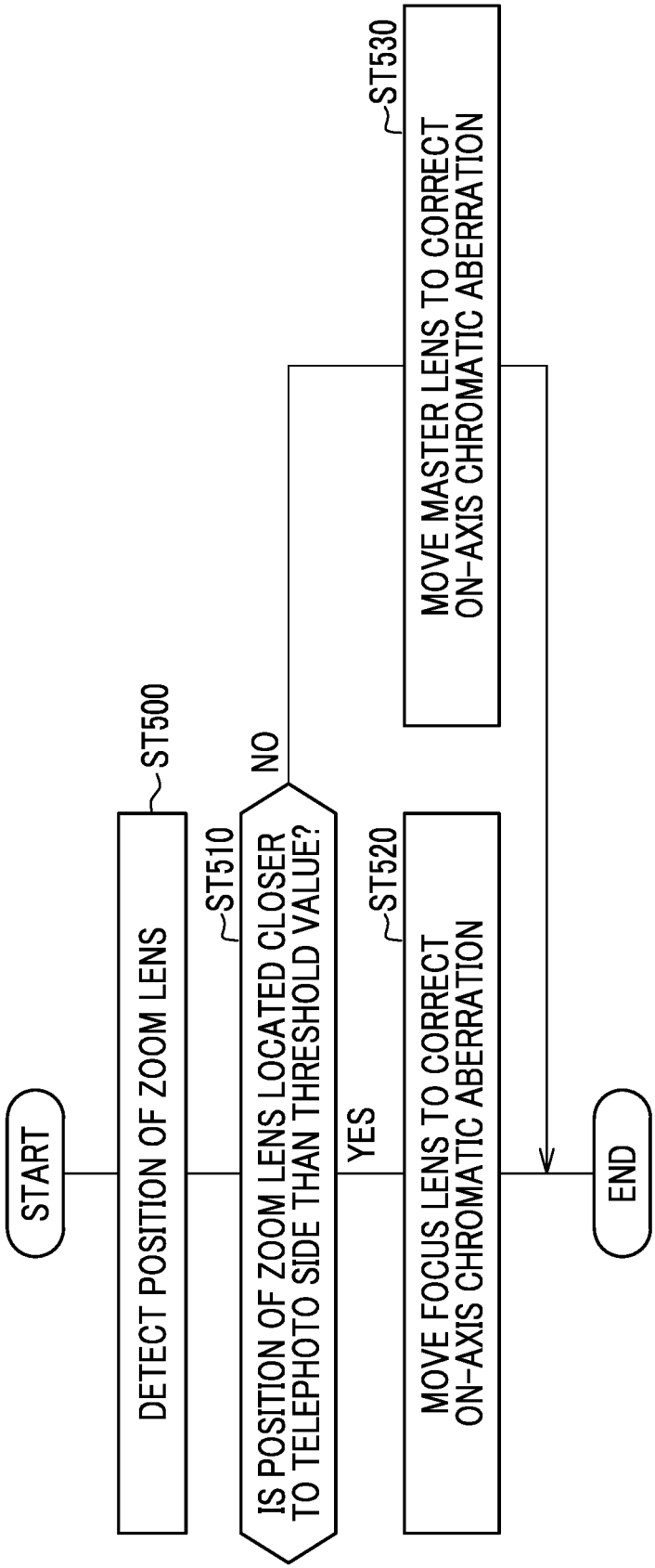

50
MONITOR DEVICE
51
CONTROL UNIT
205
21
13
41
12
40
200
14
201
28
202
38
31
ID
37
30
20
36
27
OD
35
26
25
OA

FIG. 24


START
DETECT POSITION OF ZOOM LENS
ST500
IS POSITION OF ZOOM LENS LOCATED CLOSER TO TELEPHOTO SIDE THAN THRESHOLD VALUE?
ST510
NO
YES
MOVE MASTER LENS TO CORRECT ON-AXIS CHROMATIC ABERRATION
ST530
MOVE FOCUS LENS TO CORRECT ON-AXIS CHROMATIC ABERRATION
ST520
END

IMAGING CONTROL DEVICE, OPERATION METHOD AND PROGRAM OF IMAGING CONTROL DEVICE, AND IMAGING DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of International Application No. PCT/JP2021/023987, filed on Jun. 24, 2021, which is incorporated herein by reference in its entirety. Further, this application claims priority from Japanese Patent Application No. 2020-128580, filed on Jul. 29, 2020, the disclosure of which is incorporated by reference herein in their entirety.

BACKGROUND

Technical Field

The technique of the present disclosure relates to an imaging control device, an operation method and program of the imaging control device, and an imaging device.

Related Art

Description is made in JP2004-354714A that a lens system for visible light/infrared light imaging that enables simultaneous imaging of the same subject with visible light and infrared light comprises a first imaging unit that captures a subject image formed by subject light in a first wavelength region and a second imaging unit that captures a subject image formed by the subject light in a second wavelength region, in which any one wavelength region of a visible light region or an infrared light region is set as the first wavelength region and the other wavelength region thereof is set as the second wavelength region, an optical system that forms an image of first subject light for imaging a subject by the first imaging unit on an imaging surface of the first imaging unit and comprises a focus lens that is movable in an optical axis direction in order to focus on a subject at a desired subject distance, a light-splitting unit that is disposed in the optical system and on a rear side from the focus lens and splits the subject light incident on the optical system into the first subject light and second subject light for imaging the subject by the second imaging unit, a relay optical system that forms again an image of the second subject light, which is divided by the light-splitting unit and subjected to the image forming by the action of the optical system, and comprises a correction lens movable in the optical axis direction to adjust an image-forming position, and a correction lens control unit that controls a position of the correction lens based on a position of the focus lens such that a subject distance of a subject in focus with respect to the imaging surface of the first imaging unit matches a subject distance of a subject in focus with respect to an imaging surface of the second imaging unit.

Description is made in JP2002-209126A that an imaging device that captures and images each of two predetermined electromagnetic waves, emitted by a subject, of different wavelength bands and converts the electromagnetic wave into a video signal of the subject is configured of an optical system that reflects the electromagnetic wave of any one of the wavelength bands and transmits the electromagnetic wave of the other wavelength band, a first camera that captures and images the reflected electromagnetic wave due to the reflection and converts the electromagnetic wave into a video signal, and a second camera that captures and images the transmitted electromagnetic wave due to the transmission and converts the electromagnetic wave into a video signal.

Description is made in JP1987-011384A (JP-S62-011384A) that a TV camera monitoring device that displays, on a display device, and monitors an image of a monitored device captured by a TV camera is provided with a light separator that separates incident light incident from an optical lens system into a visible ray and an infrared ray and an imaging tube for imaging each image formed by the separated visible ray and infrared ray, respectively, on the TV camera, and an image signal processing circuit that receives each image signal from the imaging tube of the TV camera and displays a visible ray image and an infrared ray image on the display device in a superimposed manner.

SUMMARY

One embodiment according to the technique of the present disclosure provides an imaging control device, an operation method and program of the imaging control device, and an imaging device capable of presenting a radiation image of a subject to a user in an easy-to-understand manner.

An imaging control device according to the present disclosure is an imaging control device that controls an operation of an imaging device having a first filter, a second filter, a correction lens, a zoom function, and an image sensor and that comprises a processor, and a memory connected to or built into the processor. The first filter transmits a visible ray. The second filter transmits an infrared ray. The processor is configured to selectively insert the first filter and the second filter into an optical path, move the correction lens along an optical axis to correct an on-axis chromatic aberration between the visible ray transmitted through the first filter and the infrared rays transmitted through the second filter, cause the image sensor to image the visible ray transmitted through the first filter to acquire a first image including a reflected image of a subject, cause the image sensor to image the infrared ray transmitted through the second filter to acquire a second image including the reflected image and a radiation image of the subject, operate the zoom function to correct a difference in angle of view between the first image and the second image caused by the movement of the correction lens along the optical axis, and output a third image including the radiation image based on the first image and the second image acquired in a state in which the difference in angle of view is corrected.

It is preferable that the processor is configured to output the third image only in a case where a preset execution condition is satisfied.

It is preferable that the execution condition includes a content that a brightness level of the reflected image included in the first image is equal to or larger than a preset threshold value.

It is preferable that the processor is configured to, in a case where the brightness level is less than the threshold value, output the first image acquired and stored in advance in a case where the brightness level is equal to or larger than the threshold value and the second image acquired in a state in which the difference in angle of view is corrected.

It is preferable that the execution condition includes a content that an instruction to execute the output of the third image is received.

It is preferable that the processor is configured to generate a difference image between the first image and the second image as the third image.

It is preferable that the processor is configured to match a brightness level of the reflected image included in the first image with a brightness level of the reflected image included in the second image and then generate the difference image.

It is preferable that the processor is configured to generate the difference image in a state in which a brightness level of the reflected image included in the first image is different from a brightness level of the reflected image included in the second image.

It is preferable that the imaging device has a zoom lens and the processor is configured to move the zoom lens along the optical axis to correct the difference in angle of view between the first image and the second image caused by the movement of the correction lens along the optical axis.

It is preferable that the processor is configured to change a movement amount of the zoom lens required for the correction of the difference in angle of view according to a position of the zoom lens in a case where the on-axis chromatic aberration is corrected.

It is preferable that the processor is configured to move the correction lens to adjust a focus deviated by the movement of the zoom lens in a case where the difference in angle of view is corrected.

An imaging device of the present disclosure comprises the imaging control device according to any one of the above.

An operation method of an imaging control device according to the present disclosure is an operation method of an imaging control device that controls an operation of an imaging device having a first filter that transmits a visible ray, a second filter that transmits an infrared ray, a correction lens, a zoom function, and an image sensor. The operation method comprises selectively inserting the first filter and the second filter into an optical path, moving the correction lens along an optical axis to correct an on-axis chromatic aberration between the visible ray transmitted through the first filter and the infrared rays transmitted through the second filter, causing the image sensor to image the visible ray transmitted through the first filter to acquire a first image including a reflected image of a subject, causing the image sensor to image the infrared ray transmitted through the second filter to acquire a second image including the reflected image and a radiation image of the subject, operating the zoom function to correct a difference in angle of view between the first image and the second image caused by the movement of the correction lens along the optical axis, and outputting a third image including the radiation image based on the first image and the second image acquired in a state in which the difference in angle of view is corrected.

A program of the present disclosure is a program that controls an operation of an imaging device having a first filter that transmits a visible ray, a second filter that transmits an infrared ray, a correction lens, a zoom function, and an image sensor. The program causes a computer to execute a process comprising selectively inserting the first filter and the second filter into an optical path, moving the correction lens along an optical axis to correct an on-axis chromatic aberration between the visible ray transmitted through the first filter and the infrared rays transmitted through the second filter, causing the image sensor to image the visible ray transmitted through the first filter to acquire a first image including a reflected image of a subject, causing the image sensor to image the infrared ray transmitted through the second filter to acquire a second image including the reflected image and a radiation image of the subject, operating the zoom function to correct a difference in angle of view between the first image and the second image caused by the movement of the correction lens along the optical axis, and outputting a third image including the radiation image based on the first image and the second image acquired in a state in which the difference in angle of view is corrected.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram showing a camera.

FIG. **2** is a diagram showing a filter unit.

FIG. **3** is a block diagram showing a computer constituting a control unit.

FIG. **4** is a block diagram of a CPU.

FIG. **5** is a diagram showing a state in which each filter is inserted into an optical path, (A) of FIG. **5** shows a state in which a first filter is inserted into the optical path, and (B) of FIG. **5** shows a state in which a second filter is inserted into the optical path.

FIG. **6** is a table showing zoom lens movement amount information.

FIG. **7** is a flowchart showing movements of a focus lens and a zoom lens in a case where the second filter is inserted into the optical path.

FIG. **8** is a flowchart showing movements of the focus lens and the zoom lens in a case where the first filter is inserted into the optical path.

FIG. **9** is a block diagram showing details of an image processing unit.

FIG. **10** is a diagram showing a determination result in a case where a first brightness level is equal to or larger than a threshold value.

FIG. **11** is a diagram showing a determination result in a case where the first brightness level is less than the threshold value.

FIG. **12** is a diagram showing a specific example of normalization by a brightness level normalization unit.

FIG. **13** is a diagram showing formation of a difference image.

FIG. **14** is a diagram showing a state in which a superimposed image of a first image and the difference image is generated.

FIG. **15** is a diagram showing a state in which a superimposed image of a first image for superimposition and a second image is generated.

FIG. **16** is a flowchart showing an operation procedure of the control unit.

FIG. **17** is a diagram showing a control unit of a second embodiment.

FIG. **18** is a diagram showing a determination result in a case where an execution instruction is received.

FIG. **19** is a diagram showing a determination result in a case where the execution instruction is not received or a cancellation instruction is received.

FIG. **20** is a block diagram showing details of an image processing unit of a third embodiment.

FIG. **21** is a diagram showing formation of a difference image of a third embodiment.

FIG. **22** is a diagram showing a state in which a superimposed image of a first image and a difference image is generated.

FIG. **23** is a diagram showing a camera of a fourth embodiment.

FIG. **24** is a flowchart showing an operation procedure of a control unit of the fourth embodiment.

DETAILED DESCRIPTION

First Embodiment

As shown in FIG. **1** as an example, a camera **10** is a surveillance camera installed in, for example, a factory, and comprises a lens barrel **11** and a main body **12**. The lens barrel **11** is provided with a lens-barrel side mount **13**, and the main body **12** is provided with a main-body side mount **14**. The lens barrel **11** is attached to the main body **12** by the lens-barrel side mount **13** and the main-body side mount **14**. An imaging optical system **20** is built into the lens barrel **11**, and an image sensor **21** is built into the main body **12**. The camera **10** is an example of an "imaging device (camera)" according to the technique of the present disclosure.

The imaging optical system **20** has a plurality of types of lenses for forming an image of subject light SL (refer to FIG. **5**) on the image sensor **21**. Specifically, the imaging optical system **20** has an objective lens **25**, a focus lens **26**, a zoom lens **27**, and a master lens **28**. Each of these lenses **25** to **28** is disposed in the order of the objective lens **25**, the focus lens **26**, the zoom lens **27**, and the master lens **28** from an object side (subject side) toward an image-forming side (image sensor **21** side). Each of the lenses **25** to **28** transmits light in a wavelength range from 400 nm to 1700 nm, that is, light in a wavelength range from a visible light range to a near infrared range. Although simplified in FIG. **1**, each of the lenses **25** to **28** is actually a lens group in which a plurality of lenses are combined.

The imaging optical system **20** also has a stop **30** and a filter unit **31**. The stop **30** is disposed between the zoom lens **27** and the filter unit **31**. The filter unit **31** is disposed between the stop **30** and the master lens **28**.

The lens barrel **11** is provided with a focus lens driving mechanism **35**, a zoom lens driving mechanism **36**, a stop driving mechanism **37**, and a filter unit driving mechanism **38**. As is well known, the focus lens driving mechanism **35** holds the focus lens **26** and includes a cam ring for focusing in which a cam groove is formed on the outer periphery thereof, a motor for focusing that rotates the cam ring for focusing around an optical axis OA to move the cam ring for focusing along the optical axis OA, and the like. Similarly, the zoom lens driving mechanism **36** holds the zoom lens **27** and includes a cam ring for zoom in which a cam groove is formed on the outer periphery thereof, a motor for zoom that rotates the cam ring for zoom around the optical axis OA to move the cam ring for zoom along the optical axis OA, and the like. In the following, a direction parallel to the optical axis OA and toward the image-forming side from the object side is denoted as an image-forming-side direction ID, and a direction parallel to the optical axis OA and toward the object side from the image-forming side is denoted as an object-side direction OD. The term "parallel" as used herein refers to parallelism in a sense including an error generally allowed in the technical field to which the technique of the present disclosure belongs, in addition to perfect parallelism.

As is well known, the stop driving mechanism **37** includes a motor that opens and closes a plurality of stop leaf blades of the stop **30** and the like. The filter unit driving mechanism **38** includes a motor that rotates the filter unit **31** in one direction with a center thereof as an axis and the like.

The motor for focusing and the motor for zoom are, for example, stepping motors. In this case, positions of the focus lens **26** and the zoom lens **27** on the optical axis OA can be derived from drive amounts of the motor for focusing and the motor for zoom. Instead of the drive amount of the motor, a position sensor may be provided to detect the positions of the focus lens **26** and the zoom lens **27**.

The filter unit driving mechanism **38** is provided with a rotation position sensor that detects a rotation position of the filter unit **31**. The rotation position sensor is, for example, a rotary encoder.

An electric component such as the motor of each of the driving mechanisms **35** to **38** is connected to a lens-barrel side contact **40** provided in the lens-barrel side mount **13**. A main-body side contact **41** is provided at a position corresponding to the lens-barrel side contact **40** of the main-body side mount **14**. A control unit **45** is connected to the main-body side contact **41**. The control unit **45** is an example of an "imaging control device (imaging controller)" according to the technique of the present disclosure. In a case where the lens barrel **11** is attached to the main body **12** via the lens-barrel side mount **13** and the main-body side mount **14**, the lens-barrel side contact **40** is in contact with the main-body side contact **41**. Accordingly, the electric components of the driving mechanisms **35** to **38** and the control unit **45** are electrically connected to each other.

The electric components of the driving mechanisms **35** to **38** are driven under the control of the control unit **45**. More specifically, the control unit **45** issues a drive signal in response to an instruction from a user input via a monitor device **50** to drive the electric components of the driving mechanisms **35** to **38**. For example, in a case where an instruction to change an angle of view to a telephoto side is input via the monitor device **50**, the control unit **45** issues the drive signal to the motor for zoom of the zoom lens driving mechanism **36** to move the zoom lens **27** to the telephoto side. The monitor device **50** is composed of, for example, a touch panel. Alternatively, the monitor device **50** is composed of, for example, a display, a keyboard, and a mouse. The monitor device **50** is installed in a remote location away from the camera **10**, for example, in a control room and is connected to the main body **12** via a connector **51**.

The motor for focusing and the motor for zoom output the drive amount to the control unit **45**. The control unit **45** derives the positions of the focus lens **26** and the zoom lens **27** on the optical axis OA from the drive amount. Further, the rotation position sensor outputs the rotation position of the filter unit **31** to the control unit **45**. Accordingly, the control unit **45** grasps the rotation position of the filter unit **31**.

The image sensor **21** has a light-receiving surface that receives the subject light SL. The image sensor **21** is disposed such that a center of the light-receiving surface matches the optical axis OA and the light-receiving surface is orthogonal to the optical axis OA. The light-receiving surface of the image sensor **21** is made of indium gallium arsenide (InGaAs). Therefore, the image sensor **21** can detect the subject image based on the light transmitted through the imaging optical system **20** in the wavelength range from 400 nm to 1700 nm, that is, the light in the wavelength range from the visible light range to the near infrared range. The term "orthogonal" as used herein refers to orthogonality in a sense including an error generally allowed in the technical field to which the technique of the present disclosure belongs, in addition to perfect orthogonality.

As shown in FIG. **2** as an example, the filter unit **31** is a circular disk in which two filters F**1** and F**2** of a first filter F**1** and a second filter F**2** are arranged in an annular shape at equal intervals (every 180° in FIG. **2**). The filter unit **31** is rotated clockwise by the filter unit driving mechanism **38** in order to switch the filters F**1** and F**2** every one frame. The term "equal interval" as used herein refers to an equal

interval in a sense including an error generally allowed in the technical field to which the technique of the present disclosure belongs, in addition to perfect equal interval. The filter unit **31** may be rotated counterclockwise. Further, the filter unit **31** may not be the circular disk, and may have a rectangular shape or another shape.

The filter unit **31** returns from a first position in the drawing disposed such that a center of the first filter F**1** matches the optical axis OA to the first position again after passing through a second position disposed such that a center of the second filter F**2** matches the optical axis OA. That is, the filters F**1** and F**2** are sequentially inserted into an optical path as the filter unit **31** rotates clockwise.

Each of the first filter F**1** and the second filter F**2** selectively transmits light in a preset wavelength range. The first filter F**1** transmits a visible ray VR (refer to FIG. **5**). The visible ray VR transmitted through the first filter F**1** is, for example, light in a wavelength range of 400 nm to 770 nm. The second filter F**2** transmits an infrared ray IR (refer to FIG. **5**). The infrared ray IR transmitted through the second filter F**2** is, for example, light in a wavelength range of 1550±100 nm (1450 nm to 1650 nm). A range of numerical values represented by using "to" means a range including numerical values described before and after "to" as a lower limit value and an upper limit value.

The image sensor **21** images the visible ray VR transmitted through the first filter F**1** to obtain a first image **60** including a reflected image RFI of the subject. Further, the image sensor **21** images the infrared ray IR transmitted through the second filter F**2** to obtain a second image **61** including the reflected image RFI and a radiation image RDI of the subject. The radiation image RDI represents a temperature of the subject. The range of the temperature of the subject represented by the radiation image RDI is, for example, 200° C. to 2000° C.

As shown in FIG. **3** as an example, the control unit **45** is formed by a computer including a central processing unit (CPU) **65**, a memory **66**, and a storage **67**. The memory **66** is, for example, a random access memory (RAM) or the like and temporarily stores various kinds of information. The storage **67**, which is a non-transitory storage medium, is, for example, a hard disk drive, a solid state drive, or the like, and stores various parameters and various programs. The CPU **65** loads the program stored in the storage **67** into the memory **66** and executes processing according to the program to integrally control the operation of each unit of the camera **10**. The memory **66** may be built into the CPU **65**. The program may be recorded and distributed on an external recording medium (not shown) and installed by the CPU **65** from the recording medium. Alternatively, the program may be stored in a server or the like connected to a network in a state of being accessible from the outside, downloaded to the memory **66** or the storage **67** by the CPU **65** in response to a request, and installed and executed.

As shown in FIG. **4** as an example, an operation program **70** is stored in the storage **67**. The operation program **70** is an application program for causing the computer constituting the control unit **45** to function as the imaging control device. That is, the operation program **70** is an example of the "program" according to the technique of the present disclosure. In addition to the operation program **70**, the storage **67** also stores a threshold value TH, a first image for superimposition **60**SP, and zoom lens movement amount information **71**.

In a case where the operation program **70** is started, the CPU **65** cooperates with the memory **66** and the like to function as an image sensor driving control unit **80**, an image processing unit **81**, a transfer control unit **82**, a focus lens driving control unit **83**, a zoom lens driving control unit **84**, a stop driving control unit **85**, and a filter unit driving control unit **86**. The CPU **65** is an example of a "processor" according to the technique of the present disclosure.

The image sensor driving control unit **80** controls the drive of the image sensor **21**. In a case where an instruction to start the imaging is input via the monitor device **50**, the image sensor driving control unit **80** causes the image sensor **21** to image the subject light SL at a preset frame rate, for example, 30 frames per second (fps). The image sensor **21** outputs an image obtained by imaging the subject light SL to the image processing unit **81**.

The image processing unit **81** performs various types of image processing on the image from the image sensor **21**. The image processing unit **81** outputs the image after the image processing to the transfer control unit **82**. The transfer control unit **82** transfers the image from the image processing unit **81** to the monitor device **50**.

The focus lens driving control unit **83** controls the drive of the focus lens driving mechanism **35**. For example, the focus lens driving control unit **83** moves the focus lens **26** along the optical axis OA via the focus lens driving mechanism **35** to correct an on-axis chromatic aberration of two types of light transmitted through the first filter F**1** and the second filter F**2** of the filter unit **31**. That is, the focus lens **26** is an example of a "correction lens" according to the technique of the present disclosure.

The zoom lens driving control unit **84** controls the drive of the zoom lens driving mechanism **36**. With the movement of the focus lens **26** along the optical axis OA to correct the on-axis chromatic aberration, a difference in angle of view is generated between the first image **60** and the second image **61**. Thus, the zoom lens driving control unit **84** moves the zoom lens **27** along the optical axis OA via the zoom lens driving mechanism **36** to correct the difference in angle of view between the first image **60** and the second image **61**, which is caused by the movement of the focus lens **26** along the optical axis OA. The zoom lens **27**, the zoom lens driving mechanism **36**, the zoom lens driving control unit **84**, and the like constitute an optical zoom function **90**. The optical zoom function **90** is an example of a "zoom function" according to the technique of the present disclosure.

The stop driving control unit **85** controls the drive of the stop driving mechanism **37** such that an amount of the subject light SL is appropriate. The filter unit driving control unit **86** controls the drive of the filter unit driving mechanism **38** such that the filters F**1** and F**2** are selectively inserted into the optical path every one frame.

As shown in (A) of FIG. **5** as an example, in a case where the first filter F**1** is inserted into the optical path, the focus lens driving control unit **83** moves the focus lens **26** to the object-side direction OD from a position in a case where the second filter F**2** in (B) of FIG. **5** is inserted into the optical path to correct the on-axis chromatic aberration. Further, the zoom lens driving control unit **84** moves the zoom lens **27** to the object-side direction OD from the position in the case where the second filter F**2** in (B) of FIG. **5** is inserted into the optical path to correct the difference in angle of view.

As shown in (B) of FIG. **5** as an example, in the case where the second filter F**2** is inserted into the optical path, the focus lens driving control unit **83** moves the focus lens **26** to the image-forming-side direction ID from a position in the case where the first filter F**1** in (A) of FIG. **5** is inserted into the optical path to correct the on-axis chromatic aberration. Further, the zoom lens driving control unit **84** moves the zoom lens **27** to the image-forming-side direction ID

from the position in the case where the first filter F1 in (A) of FIG. **5** is inserted into the optical path to correct the difference in angle of view.

In a state in which the on-axis chromatic aberration is corrected and the difference in angle of view is corrected in this manner, the image sensor **21** images the visible ray VR transmitted through the first filter F1 in the case of (A) of FIG. **5** to output the first image **60** including the reflected image RFI. Further, the image sensor **21** images the infrared ray IR transmitted through the second filter F2 in the case of (B) of FIG. **5** to output the second image **61** including the reflected image RFI and the radiation image RDI.

The on-axis chromatic aberration increases as the position of the zoom lens **27** is closer to the telephoto side. Thus, a movement amount of the focus lens **26** required for correcting the on-axis chromatic aberration increases as the position of the zoom lens **27** is closer to the telephoto side. Therefore, a movement amount of the zoom lens **27** required for correcting the difference in angle of view also changes according to the position of the zoom lens **27** in a case where the on-axis chromatic aberration is corrected. The zoom lens driving control unit **84** refers to the zoom lens movement amount information **71** to change the movement amount of the zoom lens **27** required for correcting the difference in angle of view according to the position of the zoom lens **27** in a case where the on-axis chromatic aberration is corrected.

As shown in FIG. **6** as an example, the movement amount of the zoom lens **27** required for correcting the difference in angle of view and corresponding to the position of the zoom lens **27** in a case where the on-axis chromatic aberration is corrected is registered in the zoom lens movement amount information **71**. A larger value of the movement amount of the zoom lens **27** is registered as the position of the zoom lens **27** is closer to the telephoto side. For example, a maximum value of 0.25 mm is registered in Z1 which is a position on the most telephoto side.

Each of the lenses **25** to **28** included in the imaging optical system **20** is designed for the infrared ray IR. Thus, in the case where the second filter F2 is inserted into the optical path, the focus does not deviate with the movement of the zoom lens **27** for correcting the difference in angle of view. Therefore, as shown in FIG. **7** as an example, in the case where the second filter F2 is inserted into the optical path, after the focus lens driving control unit **83** moves the focus lens **26** to correct the on-axis chromatic aberration (step ST**10**), the zoom lens driving control unit **84** may move the zoom lens **27** once to correct the difference in angle of view (step ST**11**).

On the other hand, in the case where the first filter F1 is inserted into the optical path, the focus deviates with the movement of the zoom lens **27** for correcting the difference in angle of view. Therefore, as shown in FIG. **8** as an example, in the case where the first filter F1 is inserted into the optical path, the focus lens driving control unit **83** moves the focus lens **26** to correct the on-axis chromatic aberration (step ST**10**), the zoom lens driving control unit **84** moves the zoom lens **27** to correct the difference in angle of view (step ST**11**), and then the focus lens driving control unit **83** moves the focus lens **26** again to adjust the deviated focus (step ST**12**). These steps ST**11** and ST**12** are repeated until the difference in angle of view is within an allowable range (YES in step ST**13**).

As shown in FIG. **9** as an example, the image processing unit **81** includes an image acquisition unit **100**, a brightness level calculation unit **101**, an executability determination unit **102**, a brightness level normalization unit **103**, a difference image generation unit **104**, and an image output unit **105**.

The image acquisition unit **100** acquires the first image **60** from the image sensor **21**. The image acquisition unit **100** performs various types of image processing such as gradation transformation processing on the acquired first image **60** and then outputs the first image **60** to the brightness level calculation unit **101** and the image output unit **105**. Similarly, the image acquisition unit **100** acquires the second image **61** from the image sensor **21**, performs various types of image processing on the second image **61**, and then outputs the second image **61** to the brightness level calculation unit **101** and the image output unit **105**. The first image **60** and the second image **61** acquired by the image acquisition unit **100** are images in which the difference in angle of view is corrected.

The brightness level calculation unit **101** calculates a first brightness level **110**, which is a brightness level of the reflected image RFI included in the first image **60**. The brightness level calculation unit **101** outputs the calculated first brightness level **110** to the executability determination unit **102**. Further, the brightness level calculation unit **101** outputs the calculated first brightness level **110** and the first image **60** to the brightness level normalization unit **103**. Similarly, the brightness level calculation unit **101** calculates a second brightness level **111**, which is a brightness level of the reflected image RFI included in the second image **61**. The brightness level calculation unit **101** outputs the calculated second brightness level **111** and the second image **61** to the brightness level normalization unit **103**.

The brightness level calculation unit **101** extracts, for example, a region of the second image **61** where a pixel value is equal to or larger than a preset threshold value as a region where the radiation image RDI is shown and a region of the second image **61** where the pixel value is less than the threshold value as a region where the reflected image RFI is shown. The brightness level calculation unit **101** calculates, as a second brightness level **111**, a representative value of brightness values of pixels in the region where the reflected image RFI of the second image **61** is shown. Further, the brightness level calculation unit **101** extracts a region of the first image **60** corresponding to the region where the reflected image RFI of the second image **61** is shown as a region where the reflected image RFI of the first image **60** is shown. The brightness level calculation unit **101** calculates, as the first brightness level **110**, a representative value of brightness values of pixels in the region where the reflected image RFI of the first image **60** is shown. The representative value is any one of a maximum value, a most frequent value, a median value, and an average value. The region where the reflected image RFI of the first image **60** is shown and the region where the reflected image RFI of the second image **61** is shown may be designated by the user via the monitor device **50**.

The executability determination unit **102** determines whether or not processing of outputting a difference image **115** between the first image **60** and the second image **61** is executable, based on whether or not an execution condition related to the threshold value TH and the first brightness level **110** is satisfied. The executability determination unit **102** outputs a determination result **112** of the executability to the brightness level normalization unit **103**, the difference image generation unit **104**, and the image output unit **105**.

The executability determination unit **102** determines whether or not the execution is possible at preset time

intervals. The preset time interval is, for example, every frame, every few minutes, or every few hours.

The brightness level normalization unit **103** operates only in a case where the execution condition is satisfied and the determination result **112** from the executability determination unit **102** is "execute". The brightness level normalization unit **103** normalizes the first brightness level **110** of the first image **60** in accordance with the second brightness level **111** of the second image **61**, and thus the first image **60** becomes a normalized first image **60**N. The brightness level normalization unit **103** outputs the normalized first image **60**N and the second image **61** to the difference image generation unit **104**.

Similar to the brightness level normalization unit **103**, the difference image generation unit **104** operates only in the case where the execution condition is satisfied and the determination result **112** from the executability determination unit **102** is "execute". The difference image generation unit **104** takes a difference between pixel values for each corresponding pixel of the normalized first image **60**N and the second image **61** to generate the difference image **115**. The difference image generation unit **104** outputs the generated difference image **115** to the image output unit **105**. The difference image **115** is an example of a "third image" according to the technique of the present disclosure.

In the case where the execution condition is satisfied and the determination result **112** from the executability determination unit **102** is "execute", the image output unit **105** outputs the first image **60**, the second image **61**, and the difference image **115** to the transfer control unit **82**. The transfer control unit **82** transfers the first image **60**, the second image **61**, and the difference image **115** to the monitor device **50**. On the other hand, in a case where the execution condition is not satisfied and the determination result **112** from the executability determination unit **102** is "not executed", the image output unit **105** outputs the first image for superimposition **60**SP and the second image **61** to the transfer control unit **82**. The transfer control unit **82** transfers the first image for superimposition **60**SP and the second image **61** to the monitor device **50**. That is, the image output unit **105** outputs the difference image **115** only in a case where the execution condition is satisfied.

In a case where the first brightness level **110** is equal to or larger than the threshold value TH, the first image for superimposition **60**SP is an image acquired by capturing the reflected image RFI by the image sensor **21**. The first image for superimposition **60**SP is acquired, for example, by a user's instruction via the monitor device **50** and is stored in the storage **67**. The case where the first brightness level **110** is equal to or larger than the threshold value TH is, for example, daytime. The first image for superimposition **60**SP may be acquired and stored at a time point designated in advance by the user.

As shown in FIG. **10** as an example, in a case where the first brightness level **110** is equal to or larger than the threshold value TH, the executability determination unit **102** determines that the execution condition is satisfied, and outputs a determination result **112**A of "execute". On the other hand, as shown in FIG. **11** as an example, in a case where the first brightness level **110** is less than the threshold value TH, the executability determination unit **102** determines that the execution condition is not satisfied, and outputs a determination result **112**B of "not executed". In a case where the first brightness level **110** is a value higher than the threshold value TH, the threshold value TH is set to a value with which the radiation image RDI is difficult to be observed due to brightness of the reflected image RFI of the second image **61** corresponding to the reflected image RFI of the first image **60**.

FIG. **12** shows a specific example of the normalization by the brightness level normalization unit **103**. In a case where the first brightness level **110** is "100" and the second brightness level **111** is "80", the brightness level normalization unit **103** multiplies the pixel value of each pixel of the first image **60** by 0.8, and thus the first image **60** becomes the normalized first image **60**N.

FIG. **13** shows formation of the difference image **115**. The difference image generation unit **104** subtracts the normalized first image **60**N from the second image **61** to generate the difference image **115**. The second brightness level **111** of the reflected image RFI included in the second image **61** matches the first brightness level **110** of the reflected image RFI included in the normalized first image **60**N. Thus, the difference image **115** becomes an image of substantially only the radiation image RDI with most of the reflected image RFI of the second image **61** removed.

As shown in FIG. **14** as an example, in a case where the difference image **115** or the like is transferred from the transfer control unit **82**, in the monitor device **50**, a superimposed image **120** of the first image **60** and the difference image **115** is generated and the superimposed image **120** is presented to the user by being displayed on a display (not shown). The superimposed image **120** may be generated by the image processing unit **81** and transferred to the monitor device **50** by the transfer control unit **82**. On the other hand, as shown in FIG. **15** as an example, in a case where the first image for superimposition **60**SP or the like is transferred from the transfer control unit **82** instead of the difference image **115**, in the monitor device **50**, a superimposed image **121** of the first image for superimposition **60**SP and the second image **61** is generated and the superimposed image **121** is presented to the user by being displayed on the display. In a case where the superimposed image **120** is generated, edge extraction may be performed on the first image **60** and the difference image **115**, and the superimposition may be performed such that edges of the first image **60** and the difference image **115** may be aligned with each other. The same applies to the case where the superimposed image **121** is generated. Further, a region of the radiation image RDI of the superimposed images **120** and **121** may be displayed blinking or colored. Furthermore, an edge-extracted image of the reflected image RFI of the first image **60** or the first image for superimposition **60**SP may be superimposed with the difference image **115** or the second image **61**.

Next, an action of the above configuration will be described with reference to a flowchart of FIG. **16**. The subject light SL is transmitted through the objective lens **25**, the focus lens **26**, the zoom lens **27**, the stop **30**, any of the filters F**1** or F**2** of the filter unit **31**, and the master lens **28** of the imaging optical system **20** and reaches the light-receiving surface of the image sensor **21**. The image sensor **21** images the subject light SL and outputs the image thereof under the control of the control unit **45**.

The filter unit **31** is rotated clockwise by the filter unit driving mechanism **38** that is driven under the control of the filter unit driving control unit **86**. Accordingly, the filters F**1** and F**2** are sequentially inserted into the optical path every one frame.

First, the first filter F**1** is inserted into the optical path (step ST**100**). In this case, as shown in (A) of FIG. **5**, the focus lens driving mechanism **35** that is driven under the control of the focus lens driving control unit **83** moves the focus lens

26 to the object-side direction OD. Accordingly, the on-axis chromatic aberration is corrected (step ST110). Further, the zoom lens driving mechanism 36 that is driven under the control of the zoom lens driving control unit 84 moves the zoom lens 27 to the object-side direction OD. Accordingly, the difference in angle of view is corrected (step ST120). As shown in FIG. 8, the movement of the zoom lens 27 for correcting the difference in angle of view and the movement of the focus lens 26 for focusing are actually repeated until the difference in angle of view is within the allowable range.

Under the control of the image sensor driving control unit 80, the visible ray VR transmitted through the first filter F1 is imaged by the image sensor 21, and the first image 60 including the reflected image RFI is output from the image sensor 21. The first image 60 is transmitted from the image sensor 21 to the image acquisition unit 100 of the image processing unit 81 and acquired by the image acquisition unit 100 (step ST130).

Subsequently, the second filter F2 is inserted into the optical path (step ST140). In this case, as shown in (B) of FIG. 5, the focus lens driving mechanism 35 that is driven under the control of the focus lens driving control unit 83 moves the focus lens 26 to the image-forming-side direction ID. Accordingly, the on-axis chromatic aberration is corrected (step ST150). Further, the zoom lens driving mechanism 36 that is driven under the control of the zoom lens driving control unit 84 moves the zoom lens 27 to the image-forming-side direction ID. Accordingly, the difference in angle of view is corrected (step ST160).

Under the control of the image sensor driving control unit 80, the infrared ray IR transmitted through the second filter F2 is imaged by the image sensor 21, and the second image 61 including the reflected image RFI and the radiation image RDI is output from the image sensor 21. The second image 61 is transmitted from the image sensor 21 to the image acquisition unit 100 of the image processing unit 81 and acquired by the image acquisition unit 100 (step ST170).

As shown in FIG. 9, the first image 60 is output from the image acquisition unit 100 to the brightness level calculation unit 101. The brightness level calculation unit 101 calculates the first brightness level 110 of the first image 60. The first brightness level 110 is output to the executability determination unit 102, and is compared with the threshold value TH in the executability determination unit 102.

As shown in FIG. 10, in the case where the first brightness level 110 is equal to or larger than the threshold value TH, the determination result 112A of "execute" is output from the executability determination unit 102 to the brightness level normalization unit 103, the difference image generation unit 104, and the image output unit 105 (YES in step ST180). In this case, the first image 60 becomes the normalized first image 60N in the brightness level normalization unit 103. The difference image generation unit 104 generates the difference image 115 between the normalized first image 60N and the second image 61. The difference image 115 is output from the image output unit 105 to the transfer control unit 82 together with the first image 60 and the second image 61 (step ST190).

On the other hand, as shown in FIG. 11, in the case where the first brightness level 110 is less than the threshold value TH, the determination result 112B of "not executed" is output from the executability determination unit 102 to the brightness level normalization unit 103, the difference image generation unit 104, and the image output unit 105 (NO in step ST180). In this case, the brightness level normalization unit 103 and the difference image generation unit 104 are not operated, and thus the difference image 115 is not generated.

The image output unit 105 outputs the first image for superimposition 60SP and the second image 61 to the transfer control unit 82. The series of pieces of processing of steps ST100 to ST190 are repeatedly continued until an imaging end instruction is input via the monitor device 50.

As described above, the filter unit driving control unit 86 of the CPU 65 selectively inserts the first filter F1 that transmits the visible ray VR and the second filter F2 that transmits the infrared ray IR into the optical path. The focus lens driving control unit 83 moves the focus lens 26 along the optical axis OA to correct the on-axis chromatic aberration between the visible ray VR transmitted through the first filter F1 and the infrared ray IR transmitted through the second filter F2. The image sensor driving control unit 80 causes the image sensor 21 to image the visible ray VR transmitted through the first filter F1 to acquire the first image 60 including the reflected image RFI of the subject. Further, the image sensor driving control unit 80 causes the image sensor 21 to image the infrared ray IR transmitted through the second filter F2 to acquire the second image 61 including the reflected image RFI and the radiation image RDI of the subject. The zoom lens driving control unit 84 moves the zoom lens 27 along the optical axis OA to correct the difference in angle of view between the first image 60 and the second image 61 caused by the movement of the focus lens 26 along the optical axis OA. The image processing unit 81 outputs the difference image 115 as the third image based on the first image 60 and the second image 61 acquired in the state in which the difference in angle of view is corrected. Thus, for example, as shown in FIG. 14, the superimposed image 120 of the first image 60 and the difference image 115 can be presented to the user. Therefore, the radiation image RDI can be presented to the user in an easy-to-understand manner as compared with a case where the reflected image RFI that hinders the observation of the radiation image RDI is not removed.

As shown in FIGS. 10 and 11, the image processing unit 81 outputs the difference image 115 only in a case where a preset execution condition is satisfied. The execution condition includes a content that the first brightness level 110, which is the brightness level of the reflected image RFI included in the first image 60, is equal to or larger than a preset threshold value TH. Thus, in a case where the radiation image RDI can be sufficiently observed without removing the reflected image RFI, such as at night, it is possible to save the trouble of generating and outputting the difference image 115. In other words, the difference image 115 can be generated and output only as needed. Even at night, in a case where the illumination light is emitted and the first brightness level 110 is equal to or larger than the threshold value TH, the difference image 115 is generated and output.

As shown in FIG. 11, in the case where the first brightness level 110 is less than the threshold value TH, the image processing unit 81 outputs the first image for superimposition 60SP acquired and stored in advance in the case where the first brightness level 110 is equal to or larger than the threshold value TH and the second image 61 acquired in the state in which the difference in angle of view is corrected. Thus, for example, as shown in FIG. 15, the superimposed image 121 of the first image for superimposition 60SP and the second image 61 can be presented to the user. Therefore, even in a case where it is difficult to visually recognize the reflected image RFI, such as at night, it is possible to grasp which portion of the subject has a high temperature and the like.

As shown in FIGS. **12** and **13**, the image processing unit **81** matches the first brightness level **110** of the reflected image RFI included in the first image **60** with the second brightness level **111** of the reflected image RFI included in the second image **61** and then generates the difference image **115**. Thus, it is possible to remove most of the reflected image RFI included in the second image **61** and to observe the radiation image RDI without being disturbed by the reflected image RFI.

As shown in FIG. **6**, the zoom lens driving control unit **84** changes the movement amount of the zoom lens **27** required for correcting the difference in angle of view according to the position of the zoom lens **27** in a case where the on-axis chromatic aberration is corrected. Thus, it is possible to appropriately correct the difference in angle of view according to the position of the zoom lens **27**.

As shown in FIG. **8**, the focus lens driving control unit **83** moves the focus lens **26** to adjust the focus deviated by moving the zoom lens **27** in a case where the difference in angle of view is corrected. Thus, it is possible to acquire the first image **60** in which the difference in angle of view is corrected and the focus is on.

The imaging optical system **20** may include another optical element such as a half mirror or a polarizer. Further, the filter unit **31** is not limited to being disposed between the stop **30** and the master lens **28** and may be disposed, for example, between the zoom lens **27** and the stop **30**, or at a rear stage of the master lens **28**. Furthermore, the filter unit **31** may be disposed at a front stage of the image sensor **21** of the main body **12**, instead of the lens barrel **11**.

The camera **10** to which the lens barrel **11** and the main body **12** are detachable has been illustrated, but the present invention is not limited thereto. A camera in which the lens barrel **11** and the main body **12** are not detachable and are integrated may be employed.

The filter unit **31** may include a filter for optical path length adjustment or a dimming filter, in addition to the first filter F**1** and the second filter F**2**. Further, the wavelength range of the visible ray VR transmitted through the first filter F**1** is not limited to the illustrated 400 nm to 770 nm. The wavelength range of the infrared ray IR transmitted through the second filter F**2** is also not limited to the illustrated 1450 nm to 1650 nm.

Second Embodiment

In the first embodiment, the execution condition is that the first brightness level **110** is equal to or larger than the threshold value TH, but is not limited thereto.

As shown in FIG. **17** as an example, a CPU of a second embodiment functions as an instruction receiving unit **130** in addition to each unit of the first embodiment. The instruction receiving unit **130** receives an instruction input by the user via the monitor device **50**. The instruction includes an instruction to execute the output of the difference image **115** (hereinafter referred to as execution instruction) and an instruction to cancel the execution instruction (hereinafter referred to as cancellation instruction). In a case where the execution instruction has been received, the instruction receiving unit **130** outputs to the executability determination unit **131** that the execution instruction has been received. Further, in a case where the cancellation instruction has been received, the instruction receiving unit **130** also outputs to the executability determination unit **131** that the cancellation instruction has been received. The executability determination unit **131** outputs a determination result **132** of the executability of the processing of outputting the difference image **115** between the first image **60** and the second image **61** to the brightness level normalization unit **103**, the difference image generation unit **104**, and the image output unit **105**, which are not shown.

As shown in FIG. **18** as an example, in a case where the instruction receiving unit **130** receives the execution instruction, the executability determination unit **131** determines that the execution condition is satisfied and outputs a determination result **132**A of "execute". On the contrary, as shown in FIG. **19** as an example, in a case where the instruction receiving unit **130** does not receive the execution instruction or the instruction receiving unit **130** receives the cancellation instruction, the executability determination unit **131** determines that the execution condition is not satisfied and outputs a determination result **132**B of "not executed".

As described above, in the second embodiment, the execution condition includes a content that the instruction to execute the output of the difference image **115** has been received. Thus, it is possible to decide the executability of the processing of outputting the difference image **115** according to the intention of the user.

A configuration may be employed in which the aspect of the first embodiment that the execution condition is that the first brightness level **110** is equal to or larger than the threshold value TH and the aspect of the second embodiment that the execution condition is that the instruction to execute the output of the difference image **115** has been received is selectable by the user. This configuration also includes a case of selecting both aspects of the aspect of the first embodiment that the execution condition is that the first brightness level **110** is equal to or larger than the threshold value TH and the aspect of the second embodiment that the execution condition is that the instruction to execute the output of the difference image **115** has been received. In a case where both the aspect of the first embodiment and the aspect of the second embodiment are selected, the executability determination unit **131** determines that the execution condition is satisfied in the case where the first brightness level **110** is equal to or larger than the threshold value TH and in the case where the instruction to execute the output of the difference image **115** has been received.

Third Embodiment

In the first embodiment described above, the first brightness level **110** and the second brightness level **111** are matched and then the difference image **115** is generated, but the present invention is not limited thereto.

As shown in FIG. **20** as an example, an image processing unit **140** of a third embodiment is different from the image processing unit **81** of the first embodiment in that the brightness level normalization unit **103** is not provided. Further, there are differences in that the image acquisition unit **100** outputs only the first image **60** to the brightness level calculation unit **101** and the brightness level calculation unit **101** calculates only the first brightness level **110**.

The image acquisition unit **100** directly outputs the first image **60** and the second image **61** to the difference image generation unit **104**. The difference image generation unit **104** generates a difference image **145** of the first image **60** and the second image **61** and outputs the generated difference image **145** to the image output unit **105**.

In FIG. **21** showing formation of the difference image **145**, the difference image generation unit **104** subtracts the first image **60** from the second image **61** to generate the difference image **145**. The second brightness level **111** of the reflected image RFI included in the second image **61** is

different from the first brightness level **110** of the reflected image RFI included in the first image **60** since the first brightness level **110** is not normalized as in the first embodiment. Thus, the difference image **145** is an image in which the reflected image RFI of the second image **61** remains to some extent as compared with the difference image **115** of the first embodiment.

As described above, in the third embodiment, the difference image **145** is generated without matching the first brightness level **110** of the reflected image RFI included in the first image **60** with the second brightness level **111** of the reflected image RFI included in the second image **61**. Thus, as shown in FIG. **22** as an example, in a case where the monitor device **50** generates a superimposed image **150** of the first image **60** and the difference image **145**, registration between the first image **60** and the difference image **145** can be performed with high accuracy due to the reflected image RFI remaining in the difference image **145**.

Fourth Embodiment

In a fourth embodiment shown in FIGS. **23** and **24**, the master lens **28** is used to correct the on-axis chromatic aberration in addition to the focus lens **26**.

In FIG. **23**, the camera **200** of the fourth embodiment comprises a lens barrel **201** and the main body **12**. The lens barrel **201** has substantially the same configuration as the lens barrel **11** of the first embodiment, except that a master lens driving mechanism **202** is connected to the master lens **28**. In addition, the same reference numeral is assigned to the same part as in the first embodiment, and the description thereof will be omitted.

Similar to the focus lens driving mechanism **35** and the zoom lens driving mechanism **36**, the master lens driving mechanism **202** holds the master lens **28** and includes a cam ring for master in which a cam groove is formed on the outer periphery thereof, a motor for master that rotates the cam ring for master around the optical axis OA to move the cam ring for master along the optical axis OA, and the like. The motor for master is driven under the control of the control unit **205**. The motor for master is a stepping motor, and the control unit **205** derives a position of the master lens **28** on the optical axis OA from a drive amount of the motor for master.

The control unit **205** moves the focus lens **26** along the optical axis OA via the focus lens driving mechanism **35** to correct the on-axis chromatic aberration of a plurality of types of light each transmitted through the filters F**1** and F**2**. Further, the control unit **205** moves the master lens **28** along the optical axis OA via the master lens driving mechanism **202** to correct the on-axis chromatic aberration of the plurality of types of light each transmitted through the filters F**1** and F**2**. That is, in the fourth embodiment, the master lens **28** in addition to the focus lens **26** is also an example of the "correction lens" according to the technique of the present disclosure.

As an example, as shown in a flowchart of FIG. **24**, the control unit **205** first detects the position of the zoom lens **27** (step ST**500**). In a case where the detected position of the zoom lens **27** is on the telephoto side with respect to a preset threshold value, that is, in a case where the zoom lens **27** is located closer to the telephoto side than the preset threshold value (YES in step ST**510**), the control unit **205** moves the focus lens **26** along the optical axis OA via the focus lens driving mechanism **35** to correct the on-axis chromatic aberration (step ST**520**). On the contrary, in a case where the detected position of the zoom lens **27** is on a wide angle side with respect to the threshold value, that is, in a case where the zoom lens **27** is located closer to the wide angle side than the threshold value (NO in step ST**510**), the control unit **205** moves the master lens **28** along the optical axis OA via the master lens driving mechanism **202** to correct the on-axis chromatic aberration (step ST**530**).

As described above, in the fourth embodiment, the focus lens **26** is moved to correct the on-axis chromatic aberration in the case where the zoom lens **27** is located closer to the telephoto side than the preset threshold value, and the master lens **28** is moved to correct the on-axis chromatic aberration in the case where the zoom lens **27** is located closer to the wide angle side than the preset threshold value. In the case where the zoom lens **27** is located on the telephoto side, the movement amount required for correcting the on-axis chromatic aberration is smaller in the focus lens **26** than in the master lens **28**. Thus, in the case where the zoom lens **27** is located closer to the telephoto side than the preset threshold value, a time required for correcting the on-axis chromatic aberration can be shortened by the movement of the focus lens **26**. On the other hand, in the case where the zoom lens **27** is located on the wide angle side, the movement amount required for correcting the on-axis chromatic aberration is smaller in the master lens **28** than in the focus lens **26**. Thus, in the case where the zoom lens **27** is located closer to the wide angle side than the preset threshold value, the time required for correcting the on-axis chromatic aberration can be shortened by the movement of the master lens **28**. The on-axis chromatic aberration may be corrected by movement of the focus lens **26** and the master lens **28** in parallel.

In each of the above embodiments, the difference images **115** and **145** are illustrated as the third image, but the present invention is not limited thereto.

The zoom function is not limited to the illustrated optical zoom function **90**. An electronic zoom function may be used in addition to or instead of the optical zoom function **90**. Further, the first image for superimposition **60**SP may be transferred to the monitor device **50** every one frame, or may be transferred to the monitor device **50** only once. In the case of transferring only once, the first image for superimposition **60**SP is stored in the monitor device **50** and reused.

In each of the above embodiments, the cameras **10** and **200**, which are surveillance cameras installed in a factory or the like, are shown as an example of the "imaging device" according to the technique of the present disclosure, but the present invention is not limited thereto. A digital camera used by a general user, a smart device, or the like may be used instead of the cameras **10** and **200**.

In each of the above embodiments, the aspects have been illustrated in which the control units **45** and **205** corresponding to the imaging control devices of the present disclosure are mounted on the cameras **10** and **200**, but the present invention is not limited thereto. The imaging control device of the present disclosure may be mounted on the monitor device **50**.

In each of the above embodiments, for example, as a hardware structure of the processing units executing various types of processing such as the image sensor driving control unit **80**, the image processing units **81** and **140**, the transfer control unit **82**, the focus lens driving control unit **83**, the zoom lens driving control unit **84**, the stop driving control unit **85**, and the filter unit driving control unit **86**, the image acquisition unit **100**, the brightness level calculation unit **101**, the executability determination units **102** and **131**, the brightness level normalization unit **103**, the difference image generation unit **104**, the image output unit **105**, and the instruction receiving unit **130**, various processors shown

below can be used. The various processors include a programmable logic device (PLD) which is a processor whose circuit configuration is changeable after manufacturing such as a field programmable gate array (FPGA), a dedicated electric circuit which is a processor having a circuit configuration exclusively designed to execute specific processing such as an application specific integrated circuit (ASIC), and the like, in addition to the CPU **65** which is a general-purpose processor that executes software (operation program **70**) to function as various processing units, as described above.

One processing unit may be configured by one of the various types of processors or may be configured by a combination of two or more processors of the same type or different types (for example, a combination of a plurality of FPGAs and/or a combination of a CPU and an FPGA). The plurality of processing units may be configured of one processor.

As an example of configuring the plurality of processing units with one processor, first, there is a form in which one processor is configured by a combination of one or more CPUs and software and the processor functions as the plurality of processing units, as represented by computers such as a client and a server. Second, there is a form in which a processor that realizes the functions of the entire system including the plurality of processing units with one integrated circuit (IC) chip is used, as represented by a system-on-chip (SoC) or the like. As described above, the various processing units are configured using one or more of the various processors as the hardware structure.

More specifically, a circuitry combining circuit elements such as semiconductor elements may be used as the hardware structure of the various processors.

The above various embodiments and/or various modification examples can be combined as appropriate in the technique of the present disclosure. It is needless to say that the technique of the present disclosure is not limited to each of the above embodiments and various configurations can be employed without departing from the gist. Further, the technique of the present disclosure extends to a storage medium that stores the program non-transitorily, in addition to the program.

The description content and the illustrated content described above are detailed descriptions of portions according to the technique of the present disclosure and are merely an example of the technique of the present disclosure. For example, the above description of the configurations, functions, actions, and effects is an example of the configurations, functions, actions, and effects of the portions according to the technique of the present disclosure. Therefore, it is needless to say that an unnecessary part may be deleted, a new element may be added, or a replacement may be performed to the description content and the illustrated content described above within a scope not departing from the gist of the technique of the present disclosure. In order to avoid complication and facilitate understanding of the portion according to the technique of the present disclosure, the description related to common general knowledge not requiring special description in order to implement the technique of the present disclosure is omitted in the above description content and illustrated content.

In the present specification, "A and/or B" is synonymous with "at least one of A or B". That is, "A and/or B" means that only A may be used, only B may be used, or a combination of A and B may be used. In the present specification, the same concept as "A and/or B" is also applied to a case where three or more matters are linked and expressed by "and/or".

All documents, patent applications, and technical standards described in the present specification are incorporated by reference in the present specification to the same extent as in a case where the incorporation of each individual document, patent application, and technical standard by reference is specifically and individually described.

What is claimed is:

1. An imaging controller comprising:

a processor; and

a memory connected to or built into the processor,

wherein the imaging controller controls an operation of a camera having a first filter, a second filter, a correction lens, a zoom function, and an image sensor,

the first filter is configured to transmit a visible ray,

the second filter is configured to transmit an infrared ray, and

the processor is configured to:

selectively insert the first filter and the second filter into an optical path;

move the correction lens along an optical axis to correct an on-axis chromatic aberration between the visible ray transmitted through the first filter and the infrared rays transmitted through the second filter;

cause the image sensor to image the visible ray transmitted through the first filter to acquire a first image including a reflected image of a subject;

cause the image sensor to image the infrared ray transmitted through the second filter to acquire a second image including the reflected image and a radiation image of the subject;

operate the zoom function to correct a difference in angle of view between the first image and the second image caused by the movement of the correction lens along the optical axis; and

output a third image including the radiation image based on the first image and the second image acquired in a state in which the difference in angle of view is corrected,

wherein the processor is configured to output the third image only in a case where a preset execution condition is satisfied, and the execution condition includes a content that a brightness level of the reflected image included in the first image is equal to or larger than a preset threshold value.

2. The imaging controller according to claim **1**,

wherein the processor is configured to:

in a case where the brightness level is less than the threshold value, output the first image acquired and stored in advance in a case where the brightness level is equal to or larger than the threshold value and the second image acquired in a state in which the difference in angle of view is corrected.

3. The imaging controller according to claim **1**,

wherein the execution condition includes a content that an instruction to execute the output of the third image is received.

4. The imaging controller according to claim **1**,

wherein the processor is configured to:

generate a difference image between the first image and the second image as the third image.

5. The imaging controller according to claim **4**,

wherein the processor is configured to:

match a brightness level of the reflected image included in the first image with a brightness level of the

reflected image included in the second image and then generate the difference image.

6. The imaging controller according to claim 4,

wherein the processor is configured to:

generate the difference image in a state in which a brightness level of the reflected image included in the first image is different from a brightness level of the reflected image included in the second image.

7. The imaging controller according to claim 1,

wherein the camera has a zoom lens, and

the processor is configured to move the zoom lens along the optical axis to correct the difference in angle of view between the first image and the second image caused by the movement of the correction lens along the optical axis.

8. The imaging controller according to claim 7,

wherein the processor is configured to:

change a movement amount of the zoom lens required for the correction of the difference in angle of view according to a position of the zoom lens in a case where the on-axis chromatic aberration is corrected.

9. The imaging controller according to claim 7,

wherein the processor is configured to:

move the correction lens to adjust a focus deviated by the movement of the zoom lens in a case where the difference in angle of view is corrected.

10. A camera comprising:

the imaging controller according to claim 1.

11. An operation method of an imaging controller that controls an operation of a camera having a first filter that transmits a visible ray, a second filter that transmits an infrared ray, a correction lens, a zoom function, and an image sensor, the operation method comprising:

by a processor of the imaging controller,

selectively inserting the first filter and the second filter into an optical path;

moving the correction lens along an optical axis to correct an on-axis chromatic aberration between the visible ray transmitted through the first filter and the infrared rays transmitted through the second filter;

causing the image sensor to image the visible ray transmitted through the first filter to acquire a first image including a reflected image of a subject;

causing the image sensor to image the infrared ray transmitted through the second filter to acquire a second image including the reflected image and a radiation image of the subject;

operating the zoom function to correct a difference in angle of view between the first image and the second image caused by the movement of the correction lens along the optical axis; and

outputting a third image including the radiation image based on the first image and the second image acquired in a state in which the difference in angle of view is corrected,

wherein the processor is configured to output the third image only in a case where a preset execution condition is satisfied, and the execution condition includes a content that a brightness level of the reflected image included in the first image is equal to or larger than a preset threshold value.

12. A non-transitory storage medium storing a program that controls an operation of a camera having a first filter that transmits a visible ray, a second filter that transmits an infrared ray, a correction lens, a zoom function, and an image sensor, the program causing a computer to execute a process comprising:

selectively inserting the first filter and the second filter into an optical path;

moving the correction lens along an optical axis to correct an on-axis chromatic aberration between the visible ray transmitted through the first filter and the infrared rays transmitted through the second filter;

causing the image sensor to image the visible ray transmitted through the first filter to acquire a first image including a reflected image of a subject;

causing the image sensor to image the infrared ray transmitted through the second filter to acquire a second image including the reflected image and a radiation image of the subject;

operating the zoom function to correct a difference in angle of view between the first image and the second image caused by the movement of the correction lens along the optical axis; and

outputting a third image including the radiation image based on the first image and the second image acquired in a state in which the difference in angle of view is corrected,

wherein the computer is configured to output the third image only in a case where a preset execution condition is satisfied, and the execution condition includes a content that a brightness level of the reflected image included in the first image is equal to or larger than a preset threshold value.

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